

Biochemistry-1 (Theory)
MLT 308 (Morning / Evening)
Department of Medical Laboratory Techniques



Introduction to Biochemistry

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What is Biochemistry

- ✓ Biochemistry is the application of chemistry to the study of biological processes at the cellular and molecular level.

- ✓ It emerged as a distinct discipline around the beginning of the 20th century when scientists combined chemistry, physiology and biology to investigate the chemistry of living systems by:
 - A. Studying the structure and behavior of the complex molecules found in biological material and
 - B. the ways these molecules interact to form cells, tissues and whole organism
 - C. Biochemistry has become the foundation for understanding all biological processes. It has provided explanations for the causes of many diseases in humans, animals and plants."

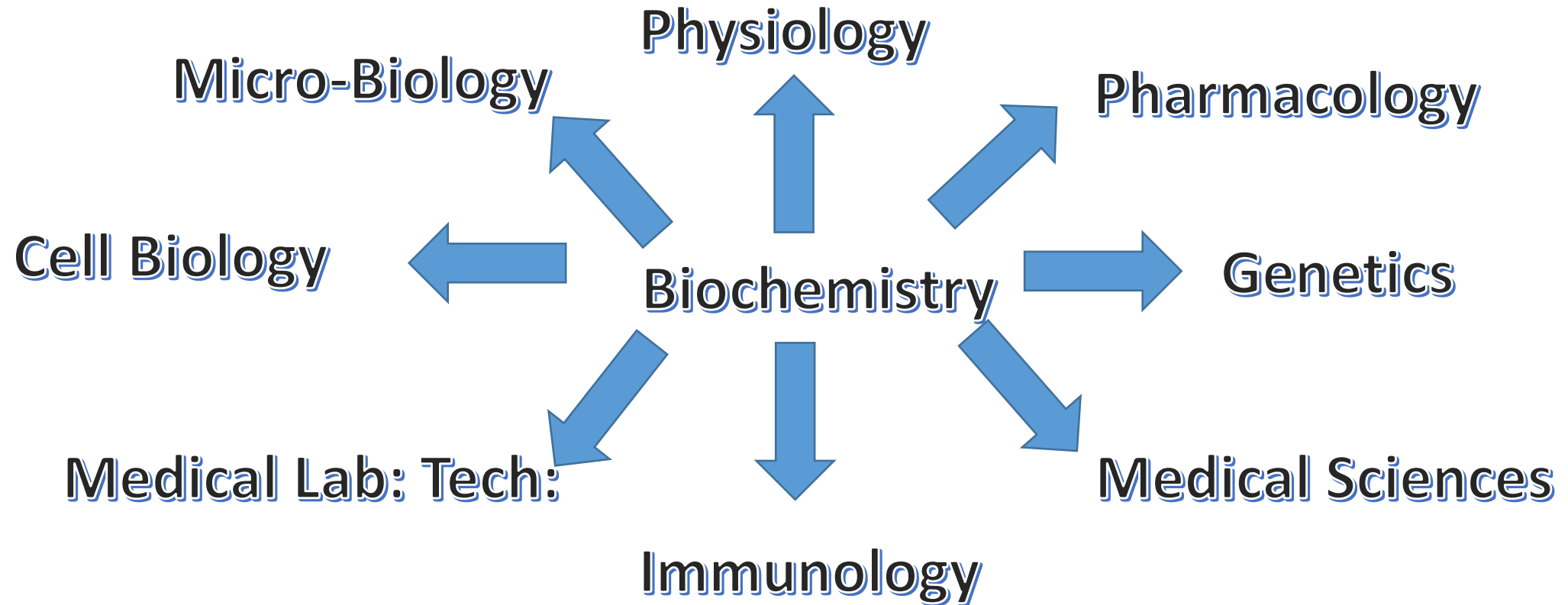
- Definition of Biochemistry

- Biochemistry or biological chemistry, is the study of chemical processes within and relating to living organisms. A sub-discipline of both chemistry and biology, biochemistry may be divided into three fields: structural biology, enzymology and metabolism.

Principles of Biochemistry

- ✓ Cells (basic structural units of living organisms) are highly organized and constant source of energy is required to maintain the ordered state.
- ✓ Living processes contains thousands of chemical reactions. Precise regulation and integration of these reactions are required to maintain life
- ✓ Certain important reactions E.g. Glycolysis is found in almost all organisms.
- ✓ All organisms use the same type of molecules: CHO, proteins, lipids & nucleic acids.
- ✓ Instructions for growth, reproduction and developments for each organism is encoded in their DNA

Biochemistry interactions with other Disciplines

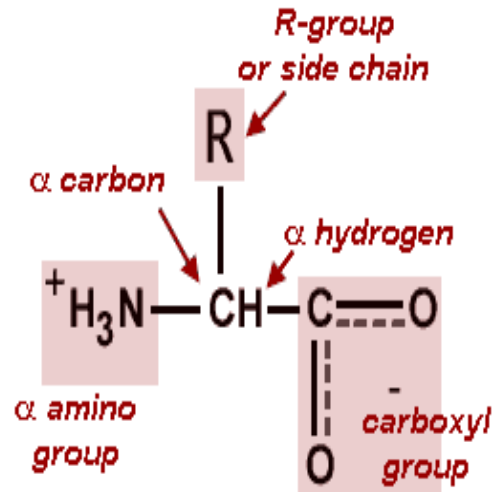


Bio-molecules

- ✓ Just like cells are building blocks of tissues likewise molecules are building blocks of cells.
- ✓ Animal and plant cells contain approximately 10, 000 kinds of molecules (bio-molecules)
- ✓ Water constitutes 50-95% of cells content by weight.
- ✓ Ions like Na^+ , K^+ and Ca^+ may account for another 1%
- ✓ Almost all other kinds of bio-molecules are organic (C, H, N, O, P, S)
- ✓ Infinite variety of molecules contain C.
- ✓ Most bio-molecules considered to be derived from hydrocarbons.
- ✓ The chemical properties of organic bio-molecules are determined by their functional groups. Most bio-molecules have more than one.

Major Classes of small Bio-molecules

✓ 1. Amino acids:



- ✓ Building blocks of proteins.
- ✓ 20 commonly occurring.
- ✓ Contains amino group and carboxyl group function groups (behavioral properties)
- ✓ R Group (side chains) determines the chemical properties of each amino acids.
- ✓ Also determines how the protein folds and its biological function.
- ✓ Individual amino acids in protein connected by peptide bond.
- ✓
- ✓ Functions as transport proteins, structural proteins, enzymes, antibodies, cell receptors.

Sugars

- ✓ Carbohydrates most abundant organic molecule found in nature.
- ✓ Initially synthesized in plants from a complex series of reactions involving photosynthesis.
- ✓ Basic unit is monosaccharaides.
- ✓ Monosaccharaides can form larger molecules e.g. glycogen, plant starch or cellulose.



Functions

- ✓ Store energy in the form of starch (photosynthesis in plants) or glycogen (in animals and humans).
- ✓ Provide energy through metabolism pathways and cycles.
- ✓ Supply carbon for synthesis of other compounds.
- ✓ Form structural components in cells and tissues.
- ✓ Intercellular communications

Fatty acids

- ✓ Are monocarboxylic acid contains even number C atoms
- ✓ Two types: saturated (C-C sb) and unsaturated (C-C db)
- ✓ Fatty acids are components of several lipid molecules.
- ✓ E.g. of lipids are triacylglycerol, steroids (cholesterol, sex hormones), fat soluble vitamins.

Functions

- ✓ Storage of energy in the form of fat
- ✓ Membrane structures
- ✓ Insulation (thermal blanket)
- ✓ Synthesis of hormones

Biochemical Reactions

- ✓ Metabolism: total sum of the chemical reaction happening in a living organism (highly coordinated and purposeful activity)
 - a) Anabolism- energy requiring biosynthetic pathways
 - b) Catabolism- degradation of fuel molecules and the production of energy for cellular function

- ✓ All reactions are catalyzed by enzymes
- ✓ The primary functions of metabolism are:
 - ✓ a. acquisition & utilization of energy
 - ✓ b. Synthesis of molecules needed for cell structure and functioning (i.e. proteins, nucleic acids, lipids, & CHO
 - ✓ c. Removal of waste products

- ✓ Even though thousands of reactions sound very large and complex in a tiny cell:
- ✓ The types of reactions are small
- ✓ Mechanisms of biochemical reactions are simple
- ✓ Reactions of central importance (for energy production & synthesis and degradation of major cell components) are relatively few in number

Frequent reaction encountered in biochemical processes

1. Nucleophilic Substitution

- ✓ One atom or group substituted for another

2. Elimination Reactions

- ✓ Double bond is formed when atoms in a molecule are removed

3. Addition Reactions:

- ✓ Two molecules combine to form a single product.
- ✓ A. Hydration Reactions
- ✓ Water added to alkene > alcohol (common addition reaction)

4. Isomerization Reactions.

- ✓ Involve intramolecular shift of atoms or groups

5. Oxidation-Reduction (redox) Reactions

- ✓ Occur when there is a transfer of e⁻ from a donor to an electron acceptor

6. Hydrolysis reactions

- ✓ Cleavage of double bond by water.

Hydrogen Ion Concentration [H⁺]

- ✓ The concentration of hydrogen ions in a solution expressed usually in moles per liter.
- ✓ It is used to determine acidic and basic nature of solutions. or in pH units and used as a measure of the acidity of the solution.
- ✓ The strength of [H⁺] in a biological system is exceedingly low. So the mol/l or g/l are not commonly used to express H⁺ ion concentration.
- ✓ Sorenson (1909) introduced the term pH to express H⁺ ion concentration.
- ✓ pH is defined as The negative logarithm of H⁺ ion concentration.

$$\text{pH} = -\log [\text{H}^+]$$

pH scale

P = power of H = Hydrogen

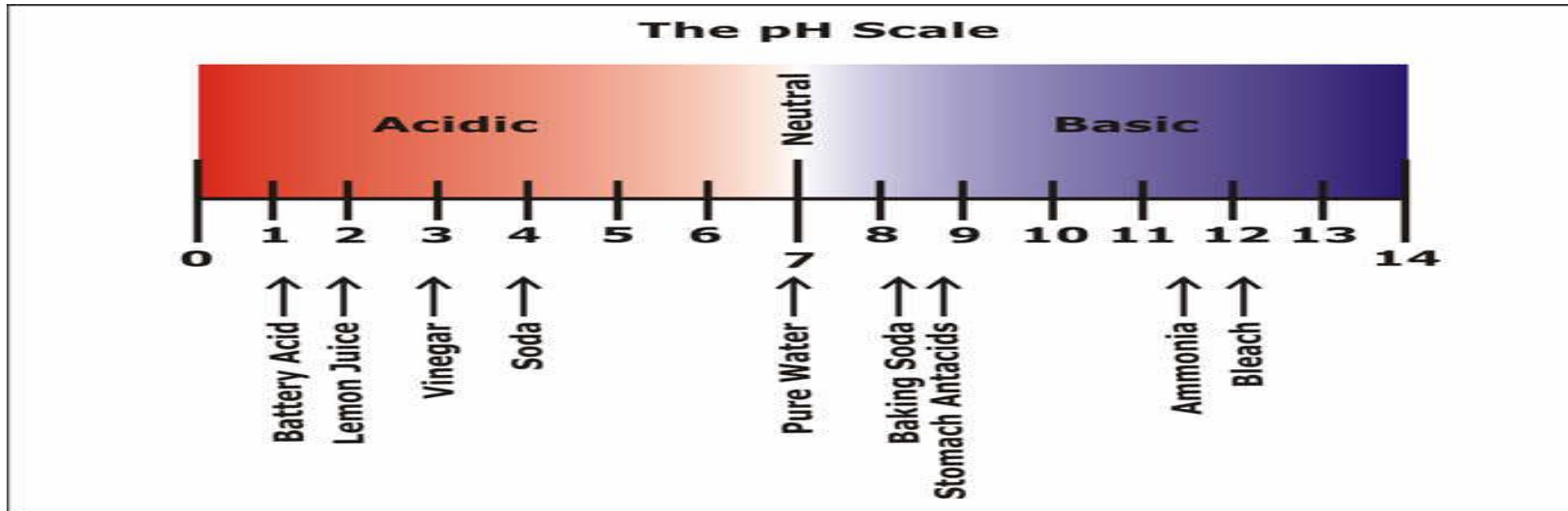
Ranges from 0-14

measures H⁺ concentration [H⁺]

the more H⁺, the more acidic the solution

Acid, Base, or Neutral

- ✓ Neutral solution: pH = 7
- ✓ Acidic solution: pH LESS THAN 7
- ✓ Basic solution: pH GREATER THAN 7



Every Acidic/Basic solution contains H^+ and OH^-

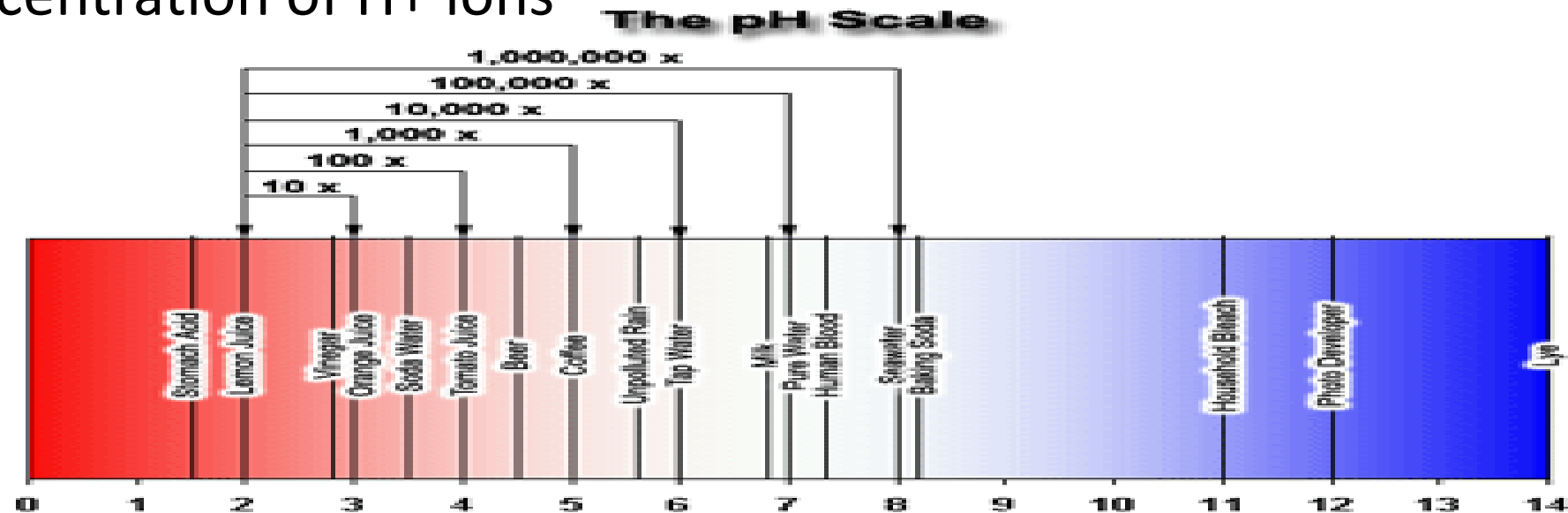
- ✓ For acids $\text{H}^{+1} > \text{OH}^{-1}$
- ✓ For bases $\text{OH}^{-1} > \text{H}^{+1}$
- ✓ when $[\text{H}^+] = [\text{OH}^-]$ the substance is neutral

so we can actually measure pH and pOH

$$\text{pH} + \text{pOH} = 14$$

- Logarithmic scale (based on powers of 10)
- ✓ each decrease of one unit of pH represents a 10x increase in H^+ concentration
 - ✓ Ex: pH 4 is ten times more acidic than pH 5
 - ✓ Ex: pH 10 is ten times more basic than pH 9

Try to remember: The lower the pH, the higher the concentration of H^+ ions



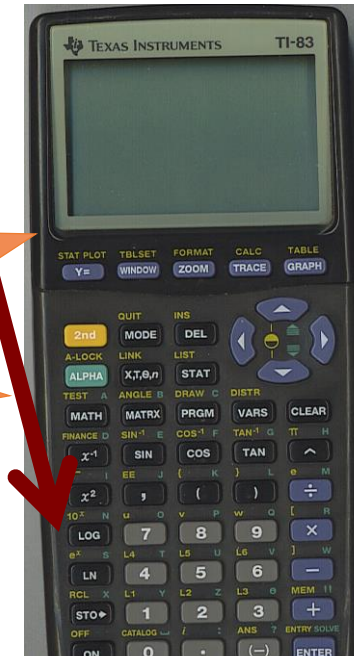
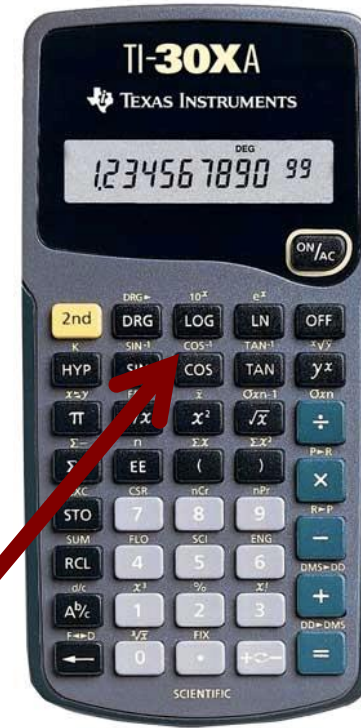
Lets Practice

1. When the pH of an aqueous solution is changed from 1 to 2, the Hydrogen ion concentration
 - a) Decreases by a factor of 2
 - b) Decreases by a factor of 10**
 - c) Increases by a factor of 2
 - d) Increases by a factor of 10
2. A solution with a pH of 2.0 has a hydronium ion concentration ten times greater than a solution with a pH of
 - a) 1.0
 - b) 0.20**
 - c) 3.0
 - d) 20
3. Which change in pH represents a hundred fold increase in the concentration of hydronium ions in a solution
 - a) pH 1 to pH 2
 - b) pH 1 to pH 3
 - c) pH 2 to pH 1
 - d) pH 3 to pH 1**

Calculating pH

- ✓ $\text{pH} = -\log [\text{H}^+]$
 - ✓ $[\text{H}^+] = \text{concentration}$
- ✓ Ex. 0.01M HCl has a pH of?
 - ✓ This means you have .01 moles of H^+
 - ✓ and .01 moles of Cl^- per every 1 L
 - ✓ $\text{pH} = -\log(0.01)$
 - ✓ $\text{pH} = 2$

We are going to
learn an easier
way!



Because it's based on powers of 10
there is a trick

10^{-x} where $x = \text{pH}$

✓ If molarity of acid is .001M $= 10^{-3}$ pH = 3

✓ If molarity of acid is .00001M $= 10^{-5}$ pH = 5

pH of a base

- ✓ Now you are looking at OH^- ions instead of H^+
 - ✓ ONLY CAN CALC **pOH**
- ✓ $\text{pOH} = -\log [\text{OH}^-]$ or our trick 10^{-x} where $x = \text{pOH}$

$$\text{pH} + \text{pOH} = 14$$

- ✓ So $14 - \text{pOH} = \text{pH}$
- ✓ Ex. 0.01M NaOH has a pH of?
 - ✓ This means you have .01 moles of OH^- and .01 moles of Na^+ per every 1 L
 - $\text{pOH} = 2$
 - $\text{pH} = 14 - 2 = 12$

Because it's based on powers of 10 there is a trick

✓ If molarity of base is .001M = 10^{-3} pOH = 3

$$\text{pH} = 14 - 3 = 11$$

✓ If molarity of base is .00001M = 10^{-5} pOH = 5

$$\text{pH} = 14 - 5 = 9$$

✓ If pH = 4

✓ $[H^{+1}] = ?$ $1 \times 10^{-4} \text{ M}$

✓ $pOH = ?$ $pH + pOH = 14$
 $4 + X = 14$
 $X = 10$

✓ $[OH^{-1}] = ?$ $1 \times 10^{-10} \text{ M} = [OH^{-1}]$

✓ If the $[\text{OH}^{-1}] = 1 \times 10^{-3} \text{ M}$

✓ $\text{pOH} = ?$ $\text{pOH} = 3$

✓ $\text{pH} = ?$

$\text{pH} + \text{pOH} = 14$
 $X + 3 = 14$
 $X = 11$

✓ $[\text{H}^{+1}] = ?$ $1 \times 10^{-11} \text{ M}$

✓ If the $[H^{+}] = 1 \times 10^{-5} \text{ M}$

✓ The pH = ? = 5

✓ The pOH = ? pH + pOH = 14
5 + x = 14
x = 9

✓ The $[OH^{-}] = ? 1 \times 10^{-9} \text{ M}$

Calc pH for

✓.01M HCl

$$10^{-2} = 2 \text{ so pH} = 2$$

✓.01M NaOH

$$10^{-2} = 2 \text{ so pOH} = 2$$

$$14 - 2 = 12$$

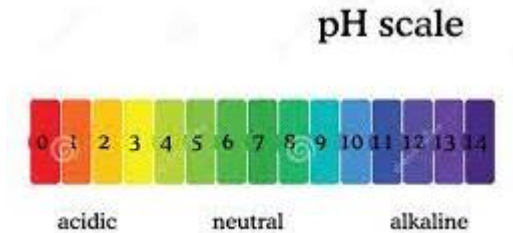
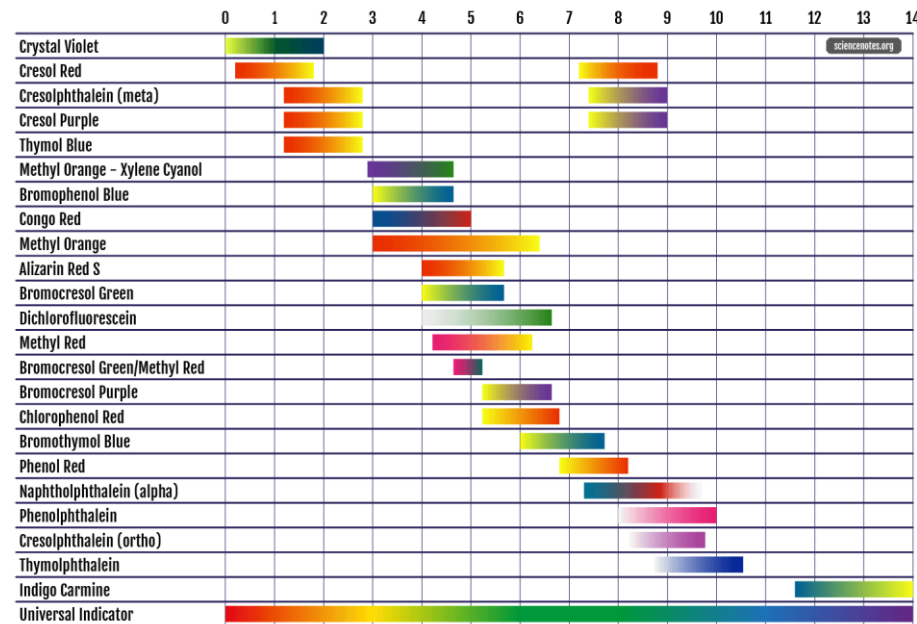
$$\text{pH} = 12$$

Method of determination of pH

To determine the pH several lab methods or used from manual to digital ways.

pH Indicator:

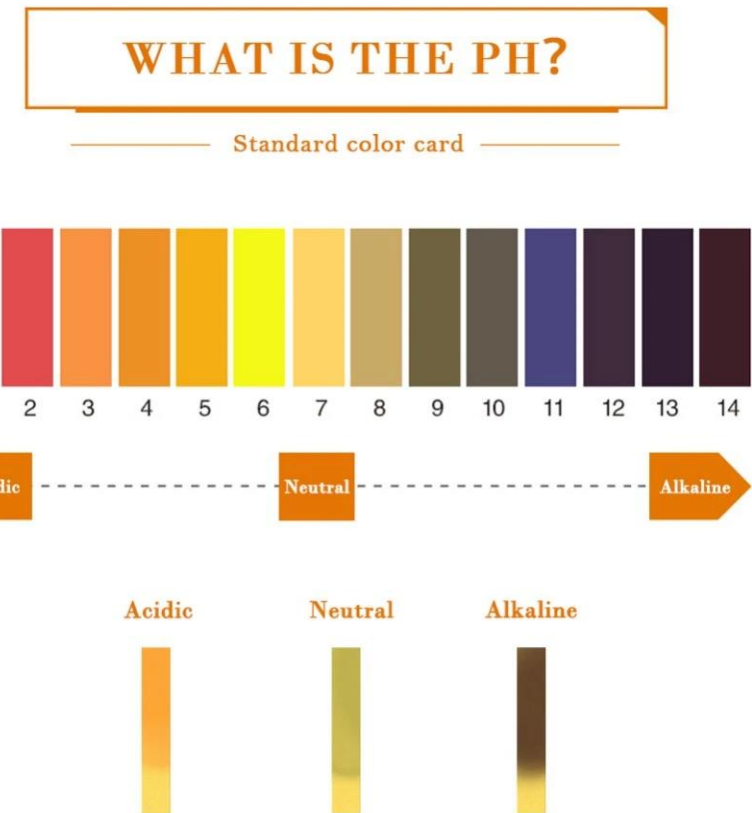
A pH indicator is a halochromic chemical compound added in small amounts to a solution so the pH of the solution can be determined visually.



pH measurement with indicator paper

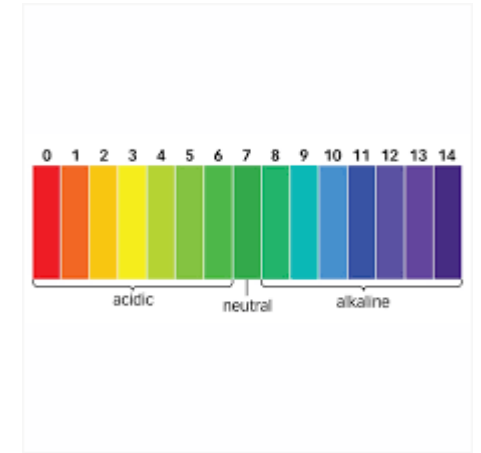
pH Paper

pH paper is small strip of paper, which is used to determine if a solution is acidic, basic or neutral. This is determined by dipping part of the paper into a solution of interest and watching the color change. ... For instance, if the paper turns a dark greenish-blue, the pH may likely be around 11 to 14.



Universal Indicator

A universal indicator is a pH indicator made of a solution of several compounds that exhibits several smooth color changes over a wide range pH values to indicate the acidity or alkalinity of solutions.



pH Meter

A pH meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH.

The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred to as a "potentiometric pH meter".

This is more precise in determining the results.

A calibration method is necessary to do at least by two known buffer solutions.



pH in living systems

Compartment	pH
Gastric acid	1
Lysosomes	4.5
Granules of chromaffin cells	5.5
Human skin (Chanson acid)	5.5
Urine	6
Neutral H ₂ O at 37 °C	6.81
Cytosol	7.2
Cerebrospinal fluid (CSF)	7.3
Blood (Chanson alkaline water)	7.34~7.45
Mitochondrial matrix	7.5
Pancreas secretions	8.1

Table 1.3 - pH range of the biological fluids

Sl. No	Biological Fluid	pH
1	Blood	7.35 - 7.40
2	Tears	7.20 - 7.40
3	Saliva	6.40 - 7.00
4	Gastric juice	1.50 - 3.00
5	Pancreatic juice	7.50 - 8.00
6	Interstitial fluid	7.20 - 7.40
7	Intracellular fluid	6.50 - 6.90
8	Urine	5.00 - 7.50
9	Cerebrospinal fluid	7.20 - 7.40

Importance of pH

- ✓ pH affects solubility of many substances.
- ✓ pH affects structure and function of most proteins - including enzymes.
- ✓ Many cells and organisms (esp. plants and aquatic animals) can only survive in a specific pH environment.

Acidity

- ✓ Acidity is a measure of a solution's capacity to react with a strong base (usually sodium hydroxide, NaOH) to a predetermined pH value.
- ✓ This measurement is based on the total acidic constituent of a solution (strong and weak acids, hydrolyzing salts, etc.)
- ✓ It is possible to have highly acidic water but have moderate pH values. Likewise, the pH of a sample can be very low but have a relatively low acidity.
- ✓ Acidity is similar to a buffer in that the higher the acidity, the more neutralizer is needed to counteract it.

Alkalinity

- ✓ Alkalinity is the measure of a solution's capacity to react with a strong acid (usually sulfuric acid H_2SO_4) to a predetermined pH.
- ✓ The alkalinity of a solution is usually made up of carbonate, bicarbonate, and hydroxides.
- ✓ Similar to acidity, the higher the alkalinity is, the more neutralizing agent is needed to counteract it.
- ✓ In general, a treatment plant and its collection system operates better with wastewater lower in acidity and higher in alkalinity.
- ✓ Acidity and alkalinity analyses each comprise of a simple titration. Basically, acidity is determined by titrating the sample with sodium hydroxide to a pH of 8.3 (often called the phenolphthalein acidity – this term dates back to the time before electronic pH meters).
- ✓ Alkalinity is determined by titration with sulfuric acid to a pH of 4.5.

Buffers

✓ Definition: A solution that resists change in pH.

A buffer solution (more precisely, pH buffer or hydrogen ion buffer) is an aqueous solution consisting of a mixture of a weak acid and its conjugate base, or vice versa.

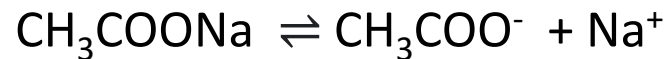
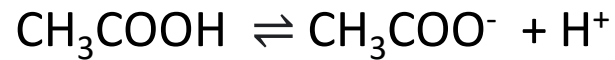
- Typically a mixture of the acid and base form of a chemical
- Can be adjusted to a particular pH value

✓ Why use them?

- Enzyme reactions and cell functions have optimum pH's for performance
- Important anytime the structure and/or activity of a biological material must be maintained

How buffers work (Mechanism)

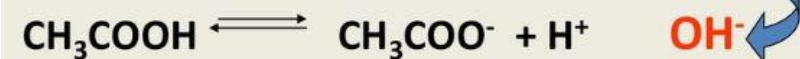
- ✓ Equilibrium between acid and base.
- ✓ Example: A buffer pair of Acetic Acid and Sodium Acetate (Acetate buffer)



- ✓ If more H^+ is added to this solution, it simply shifts the equilibrium to the left, absorbing H^+ , so the $[\text{H}^+]$ remains unchanged.
- ✓ If H^+ is removed (e.g. by adding OH^-) then the equilibrium shifts to the right, releasing H^+ to keep the pH constant.

Mechanism of buffer action

Acetate buffer



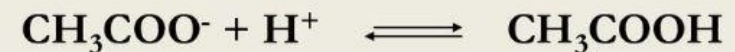
+ 1 mole NaOH

1 mole



+1 mole HCL

(weak electrolyte)

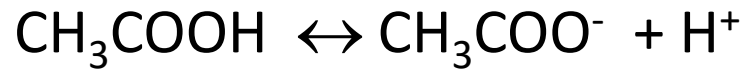


1 mole (weak electrolyte)



Limits to the working range of a buffer

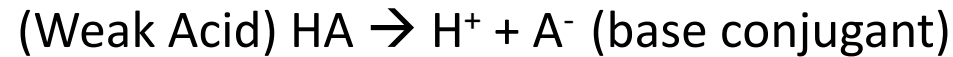
- ✓ Consider the previous example:



- ✓ If too much H^+ is added, the equilibrium is shifted all the way to the left, and there is no longer any more CH_3COO^- to “absorb” H^+ .
- ✓ At that point the solution no longer resists change in pH; it is useless as a buffer.
- ✓ A similar argument applies to the upper end of the working range.

Chemistry of buffers

- ✓ K_a = equilibrium constant for H^+ transfer
- ✓ also described as the dissociation constant
- ✓ the tendency of an acid to dissociate.



$$K_a = [A^-] [H^+] / [AH] = [\text{base}] [H^+] / [\text{acid}]$$

- ✓ Weak acids have low values , contribute few H^+ ions...
- ✓ Because we are usually dealing with very small concentrations, log values are used...
- ✓ The log constant = $pK_a = -\log_{10} K_a$
- ✓ SO! Since pK is the negative log of K, weak acids have high values like (-2 – 12).
- ✓ Lower than -2 considered strong acid.
- ✓ HCl = -9.3 – very low on complete dissociation, It is very strong acid.

Chemistry of buffers

- ✓ First rearrange the first equation and solve for $[H^+]$

$$[H^+] = K_a \times [\text{acid}]/[\text{base}]$$

- ✓ Then take the log of both sides

$$\log_{10}[H^+] = \log_{10}K_a + \log_{10} [\text{acid}]/[\text{base}]$$

↑
-pH

↑
-pK_a

- ✓ $-pH = -pK_a + \log_{10} [\text{acid}]/[\text{base}]$
- ✓ Multiply both sides by -1 to get the Henderson-Hasselbach equation

$$\mathbf{pH = pK_a - \log_{10} [\text{acid}]/[\text{base}]}$$

Chemistry of buffers

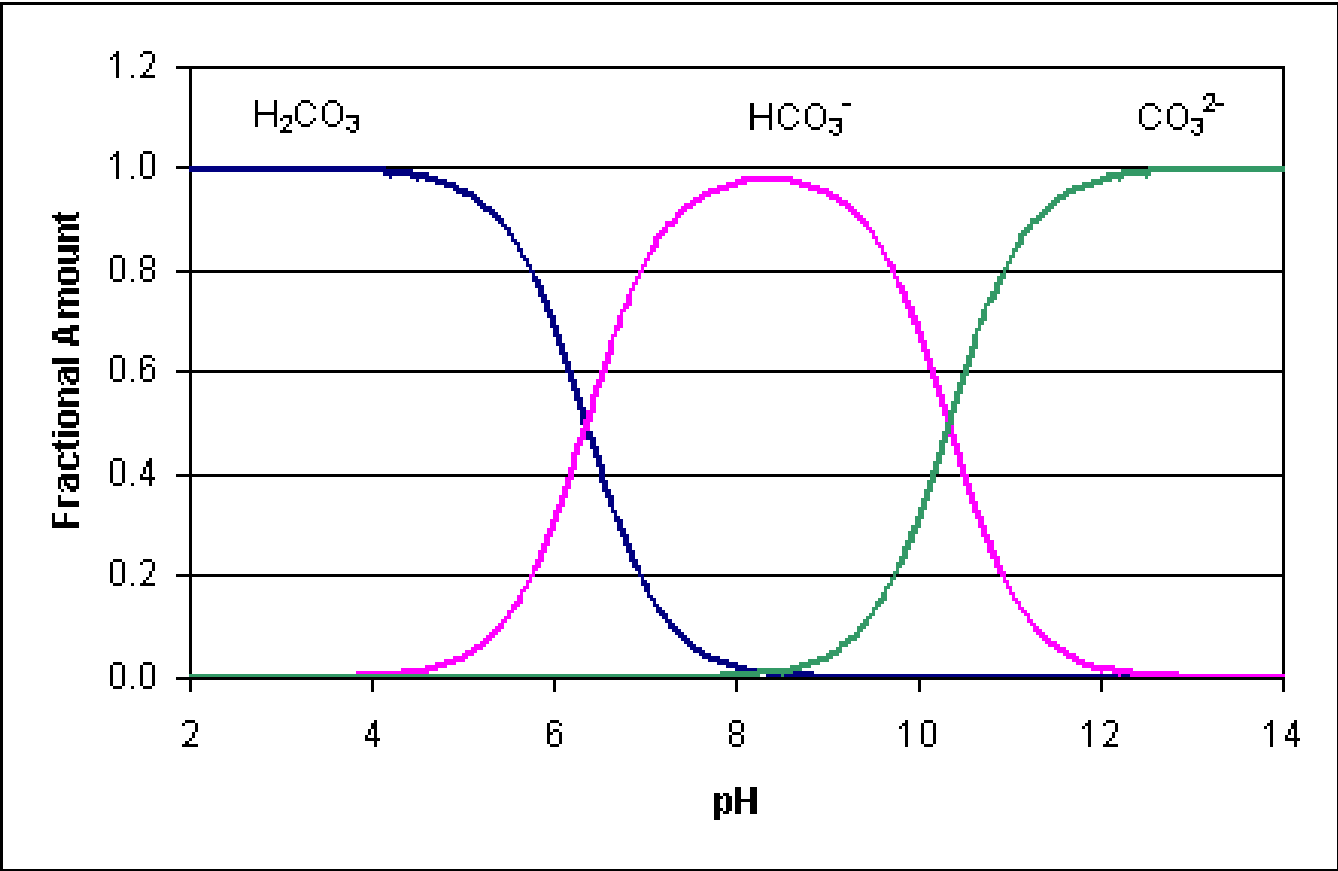
- ✓ What happens when the concentration of the acid and base are equal?
 - ✓ Example: Prepare a buffer with 0.10M acetic acid and 0.10M acetate
 - ✓ $\text{pH} = \text{pKa} - \log_{10} [\text{acid}]/[\text{base}]$
 - ✓ $\text{pH} = \text{pKa} - \log_{10} [0.10]/[0.10]$
 - ✓ $\text{pH} = \text{pKa}$
 - ✓ Thus, the pH where equal concentrations of acid and base are present is defined as the pKa
- ✓ A buffer works most effectively at pH values that are ± 1 pH unit from the pKa (the buffer range)

Drives equilibria and reversible states of compounds

Carbonic Acid

Bicarbonate

Carbonate



Factors in choosing a buffer

- ✓ Be sure it covers the pH range you need
 - Generally: pK_a of acid ± 1 pH unit
 - Consult tables for ranges or pK_a values
- ✓ Be sure it is not toxic to the cells or organisms you are working with.
- ✓ Be sure it would not confound the experiment (e.g. avoid phosphate buffers in experiments on plant mineral nutrition).

What to report when writing about a buffer:

- ✓ The identity of the buffer (name or chemicals)
- ✓ The molarity of the buffer
- ✓ The pH of the buffer
- ✓ Examples:
 - “We used a 0.5M Tris buffer, pH 8.0.”
 - “The reaction was carried out in a 0.1M boric acid – sodium hydroxide buffer adjusted to pH 9.2.”

Three basic strategies for making a buffer

1. Guesswork – mix acid and base at the pH meter until you get the desired pH.
 - ✓ Wasteful on its own, but should be used for final adjustments after (2) or (3).
2. Calculation using the Henderson-Hasselbach equation.
3. Looking up recipe in a published table.

Calculating buffer recipes

- ✓ Henderson-Hasselbach equation

$$\text{pH} = \text{pKa} - \log_{10} [\text{acid}]/[\text{base}]$$

- ✓ Rearrange the equation to get

$$10^{(\text{pKa}-\text{pH})} = [\text{acid}]/[\text{base}]$$

- ✓ Look up pKa for acid in a table. Substitute this and the desired pH into equation above, and calculate the approximate ratio of acid to base.
- ✓ Because of the log, you want to pick a buffer with a pKa close to the pH you want.

The Henderson–Hasselbalch equation can be used to estimate the pH of a buffer solution. The numerical value of the acid dissociation constant, K_a , of the acid is known or assumed.

The pH is calculated for given values of the concentrations of the acid, HA and of a salt, MA, of its conjugate base, A^- ;

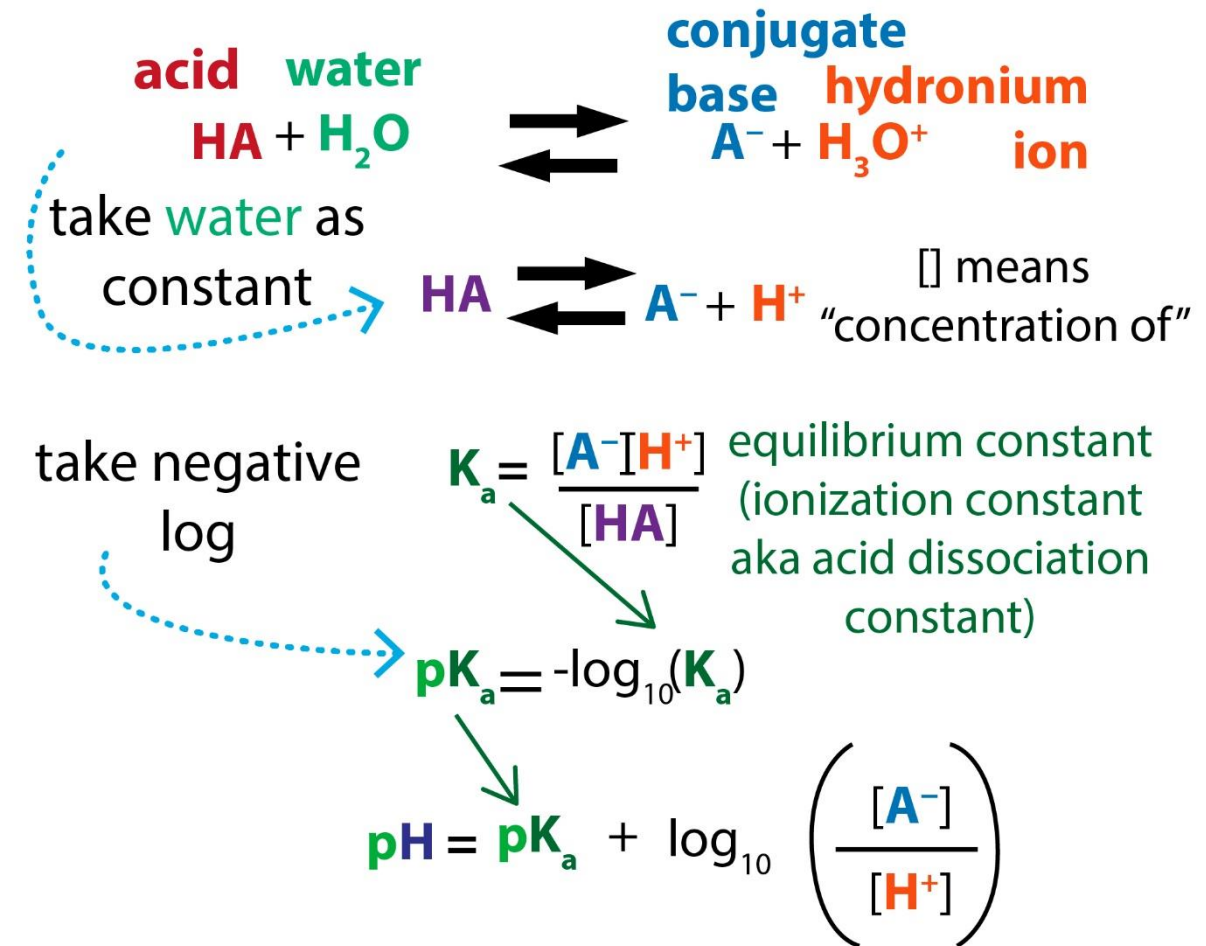
Henderson Hasselbalch Equation

$$\text{pH} = \text{pK}_a + \log \frac{[\text{conjugate base}]}{[\text{weak acid}]} \text{ (for weak acid)}$$

$$\text{pOH} = \text{pK}_b + \log \frac{[\text{conjugate acid}]}{[\text{weak base}]} \text{ (for weak base)}$$

Henderson-Hasselbalch equation

gives a way to go back and forth between pH & pKa showing you how a buffer decides where pH will stay!



Example

- ✓ You want to make about 500 mL of 0.2 M acetate buffer (acetic acid + sodium acetate), pH 4.0.
- ✓ Look up pKa and find it is 4.8.
- ✓ $10^{(4.8 - 4.0)} = 10^{0.8} = 6.3 = [\text{acid}]/[\text{base}]$
- ✓ If you use 70 mL of base, you will need 6.3X that amount of acid, or 441 mL. Mix those together and you have 511 mL (close enough).

Importance of Buffer Solution

By [Mike Charmaine](#), eHow Contributor
updated: June 17, 2010

Buffer solutions are solutions in water that mark the combination of acids and bases. They help in neutralization reaction to a certain extent. Acidic buffer solutions are those that have strong acids and weak bases as their components. They are used for neutralizing alkaline solutions. Alkaline or basic buffer solutions are those that have strong alkalis and weak acids in the mixture. They are used for neutralizing acidic aqueous solutions.

Blood as a Buffer Solution

1. Blood itself tends to be a buffer solution by keeping its pH value constant. Buffer solutions help in the adjustment of the nature of blood. They play a major role in the anatomy of every human being. If the alkaline nature of blood increases, buffer solutions tend to bring down the pH value of blood. The reverse happens if blood becomes acidic. Acidic nature increases the pH value of blood.

Role of Buffers in Human Body

2. Reactions inside the human body take place in the blood plasma. These reactions might fail to happen if the pH changes. For complete reaction to take place, the pH of the blood should remain constant. Biochemical reactions are quite sensitive to the nature of blood. The reaction inverts by changes in the pH of blood. However, these buffers generally prevent such mishap. These changes also affect the biological activity of a human being.

Importance of Buffer Solutions to Human Body

3. If the pH value of blood remains in either alkaline or acidic form then it could prove harmful to a human being. It may even lead to death. This may prevent the working of some organs also. This serves to be the best example as to why buffer solutions are important for the body. Buffer solutions prevent the body from permanent damage.

Action of Buffers in Blood Plasma

4. When carbon dioxide dissolves in blood, it decreases the pH value, thereby increasing the acidic content of blood. In this case, alkaline buffers come into play. They tend to mix with the plasma of blood and then neutralize its value. The same happens in the plasma when the alkaline value of blood increases. In this case, acidic buffers in the blood plasma play their role. If the alkalinity or the

acidity of blood pertains for a longer period, the body gets into a hazardous state, which if left unaddressed, can prove fatal.

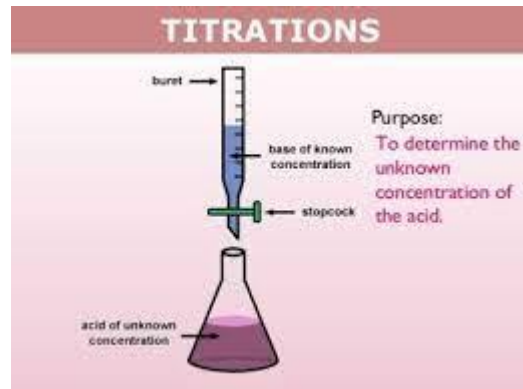
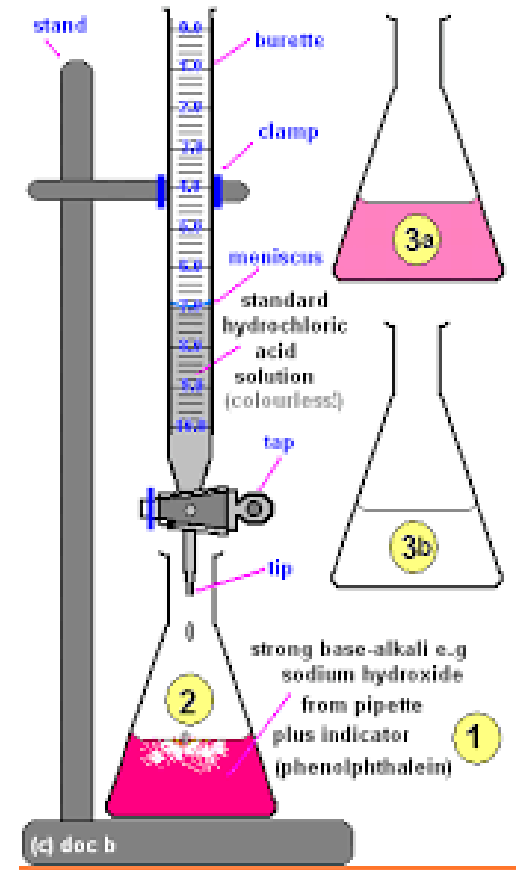
Changes in Body due to Buffer Solutions

5. Without buffer solutions, our body may undergo a lot of changes. The enzyme action is regulated by blood. Therefore, the change of pH value also affects the enzymes indirectly. Enzyme actions require low energy involvement. Changes in the temperature of body can effect enzyme action to a wider range. This serves to be the primary reason as to why buffer solutions play a major role in the human body

Buffer	pKa (25°C)	Useful pH Range
TFA	0.5	<1.5
Sulfonate	1.8	<1-2.8
Phosphate	2.1	1.1-3.1
Chloroacetate	2.9	1.9-3.9
Formate	3.8	2.8-4.8
Acetate	4.8	3.8-5.8
Sulfonate	6.9	5.9-7.9
Phosphate	7.2	6.2-8.2
Ammonia	9.2	8.2-10.2
Phosphate	12.3	11.3-13.3

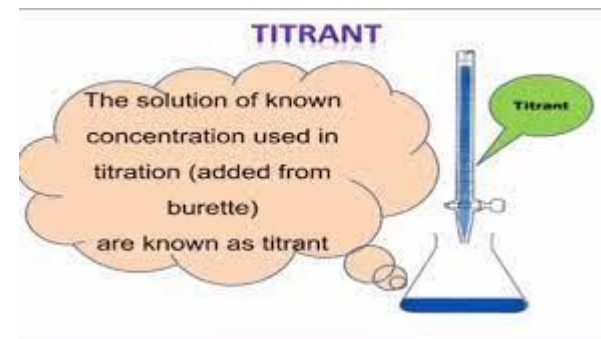
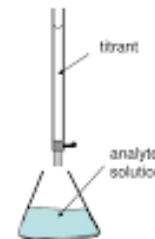
What is Titration Method

- ✓ A titration is a technique where a solution of known concentration is used to determine the concentration of an unknown solution.
- ✓ Typically, the titrant (the know solution) is added from a burette to a known quantity of the analyte (the unknown solution) until the reaction is complete.
- ✓ Knowing the volume of titrant added allows the determination of the concentration of the unknown.
- ✓ Often, an indicator is used to usually signal the end of the reaction, the endpoint.



Titration Definitions

- **Titrant:**
 - Reagent solution added out of buret (concentration usually known)
- **Analyte solution:**
 - Solution containing analyte
- **Equivalence Point:**
 - point where ratio of moles of titrant to moles of analyte is equal to the stoichiometric ratio



Titrations

Titration

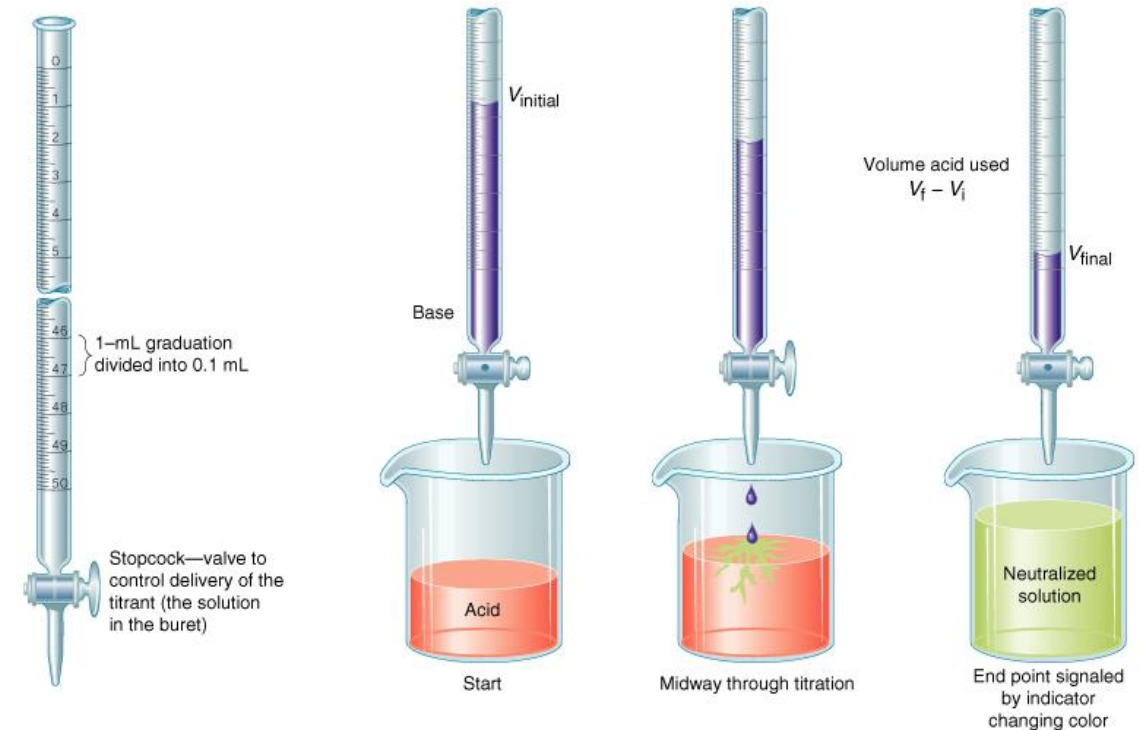
An unknown amount of one reactant is combined exactly with a precisely measured volume of a standard solution of the other.

End-point

When exactly stoichiometric amounts of two reactants have been combined.

Indicator

Substance added to aid in detection of the endpoint (usually via a color change)



Indicator	Acid Color	Base Color	pH Range
Methyl violet	yellow	violet	0 - 2
Bromophenol blue	yellow	blue-violet	3.0 - 4.5
Methyl orange	red	yellow	3.1 - 4.4
Universal indicator	red	blue-violet	4.0 - 10.0
Litmus	red	blue	4.7 - 8.2
Methyl red	red	yellow	4.8 - 6.2
Bromothymol Blue	yellow	blue	6.0 - 7.6
Phenol red	yellow	red	6.8 - 8.4
Phenolphthalein	colorless	red	8.2 - 10.0
Alizarin yellow	yellow	red	10.0 - 12.0

Colloidal State

A colloidal state of matter is a state in which the size of the particles is such that (1 nm - 100 nm) that they can pass through filter paper but not through animal or vegetable membrane.

When a particle has < 1 , it is in true solution. Particles > 100 nm, the matter exist as visible precipitate.

The colloidal state is intermediate in between true solutions and precipitate.

It is heterogeneous with two phases.

1. Dispersed phase: It constitutes the colloidal particles, also called internal phase.
2. Dispersion phase: The medium in which colloidal particles are suspended.

History

Thomas Graham (1861) known as father of colloidal chemistry.

He divided substances in two categories. Crystalloids, Colloids

Crystalloids: A solution can freely pass through parchment membrane (e.g. Sugar, Urea, NaCl)

Colloids (Glue like): The substance that is retained by parchment membrane (e.g. gum, gelatin, albumin).

The classification is no longer exist, because any substance can be converted to colloid by suitable means.

E.g. NaCl in benzene forms colloids.

Colloids

There are three types of dispersed systems namely molecular, colloidal, and coarse dispersions. Molecular dispersions are homogeneous in character and form true solutions.

It is important to know that the only difference between molecular, colloidal, and coarse dispersions is the size of the dispersed phase and not its composition.

Colloidal dispersions can be characterized as containing particles in the size range of between approximately 1 nm and 1 micrometer, however a smaller size range of up to 500 nm is also quoted.

Dispersed Systems:

Classification Based on Size

Class	Size	Examples
Molecular dispersion	$< 1.0 \text{ nm}$	Oxygen gas, ordinary ions, glucose
Colloidal dispersion	$1.0 \text{ nm to } 0.5 \mu\text{m}$	Silver sols, natural and synthetic polymer latices
Coarse dispersion	$> 0.5 \mu\text{m}$	Sand, pharmaceutical emulsions & dispersions, red blood cells

Class	Particle size	Characteristic of system	Example
Molecular dispersion	Less than 1 nm	Invisible in electron microscope Pass through ultrafilter (0.01 micron) and semipermeable membrane Undergo rapid diffusion	Oxygen molecules, ordinary ions, glucose
Colloidal dispersion	From 1 nm to 0.5 μm	Not resolved (to determine) by ordinary microscope (although may be detected under ultramicroscope,) Visible in electron microscope, Pass through filter paper, Do not pass semipermeable membrane, Diffuse very slowly	Colloidal silver sols, natural and synthetic polymers, cheese, butter, jelly, paint, milk, shaving cream, etc.

Class	Particle size	Characteristic of system	Example
Coarse dispersion	Greater than 0.5 μm	Visible under microscope; Do not pass through normal filter paper; Do not dialyze through semipermeable membrane; Do not diffuse	Grains of sand, most pharmaceutical emulsions and suspensions, red blood cells

Types of colloids

Colloids are usually classified according to:

1- The original states of their constituent parts

Dispersed Phase	Dispersion Medium	Common Name	Examples
Solid	Solid	Solid Sol	Coloured gemstones, coloured glasses
Solid	Liquid	Sol	Paints, muddy water, gold sol, starch sol, arsenous sulphide sol
Solid	Gas	Aerosol	Smoke, dust
Liquid	Solid	Gel	Gellies, cheese
Liquid	Liquid	Emulsion	Milk, cod liver oil
Liquid	Gas	Liquid aerosol	Mist, fog, cloud
Gas	Solid	Solid foam	Foam rubber, pumice stone
Gas	Liquid	Foam	Froth, whipped cream

Types of colloidal systems:

Dispersed phase means the substance distributed in the dispersion medium in the form of colloidal particles and dispersion medium or continuous phase means the medium in which the substance is dispersed in the form of colloidal particles.

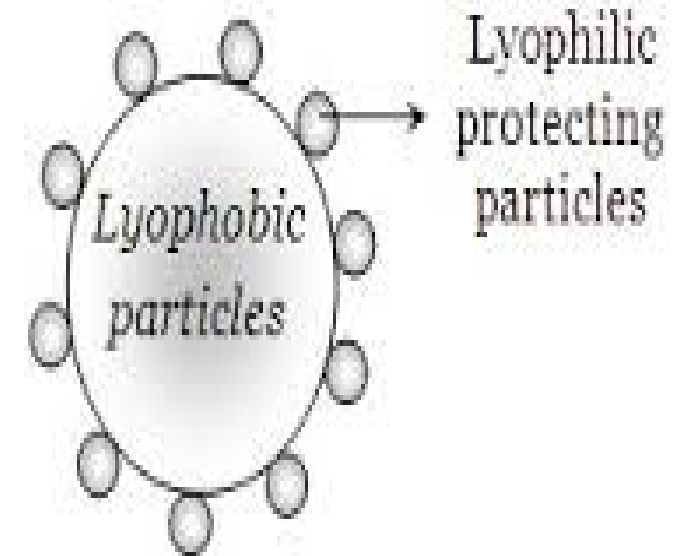
Type	Disperse phase	Continuous phase	Example
Aerosol, Smoke	Liquid	Gas	smoke
Fog, mist aerosol	Solid	Gas	exhaled breath
Foam	Gas	Liquid	Whipped cream, beaten eggs.
Emulsion	Liquid	Liquid	Milk, Mayonnaise
Sol, Colloidal solution, gel, paste	Solid	Liquid	Cloudy beer, milk, gelatin, tomato paste
Solid foam	Gas	Solid	Ice cream, Meringue

Classification of colloids

Colloidal sols are divided into two categories :

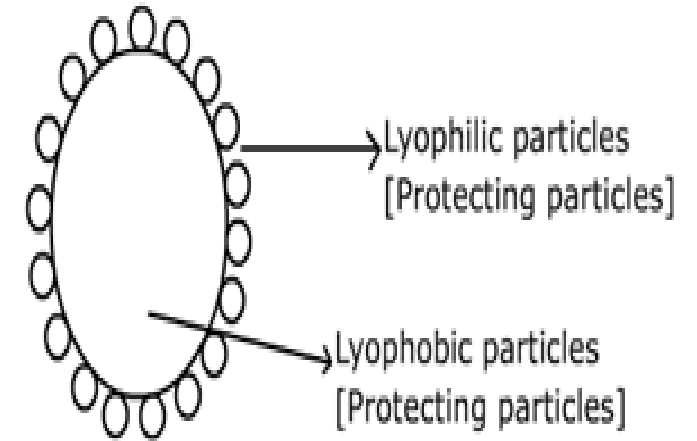
lyophilic colloids:

- ✓ Lyophilic colloids are liquid loving colloids (Lyo means solvent and philic means loving).
- ✓ When these colloids are mixed with the suitable liquid, high force of attraction exists between colloidal particles and liquid.
- ✓ This result in formation of very stable solution called lyophilic sol.
- ✓ These sols are formed by substances like gums, starch and proteins.
- ✓ Lyophilic sol can be easily prepared by directly mixing colloid with the liquid.
- ✓ The system is said to be hydrophilic if the dispersion medium is water.
- ✓ Lipophilic or oleophilic substances have a strong affinity for oils i.e., mineral oil, benzene, carbon tetrachloride, vegetable oils (e.g., cottonseed or peanut oil), and essential oils (e.g., lemon or peppermint oil).



Protective action of lyophilic colloids

- ✓ Lyophobic sols are unstable and are easily precipitated by addition of electrolytes.
- ✓ It is observed that the addition of certain lyophilic colloids like gums, soaps, gelatin etc. to lyophobic colloids render lyophobic colloids difficult to coagulate by addition of electrolytes. This process is known as protection and lyophilic colloids are termed as protective colloids.
- ✓ **Gold number**: gold number of a protective colloid is the minimum weight of it in milligrams which must be added to 10ml of a standard red gold sol so that no coagulation of gold sol takes place when 1ml of 10% sodium chloride solution is rapidly added to it.
- ✓ Smaller the gold number of protective colloid greater is its protective action.

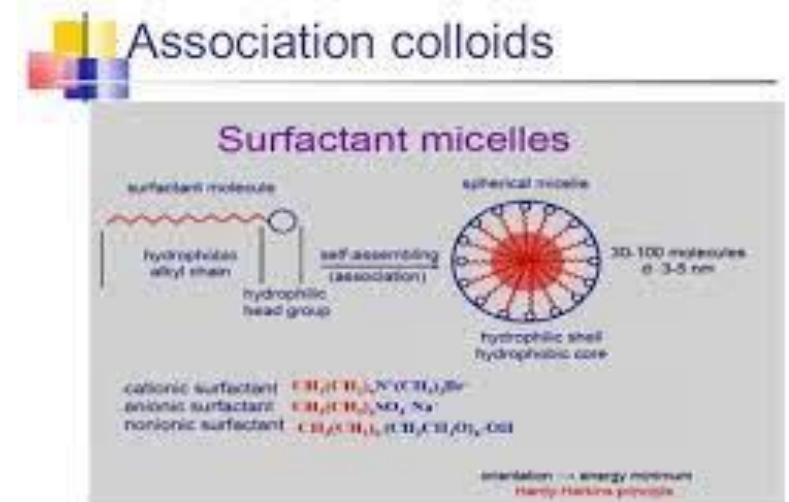
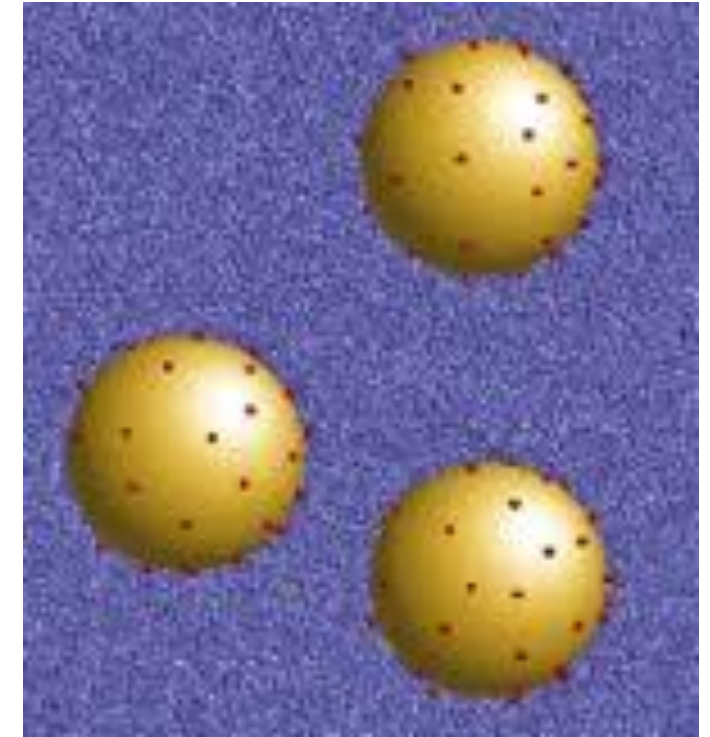
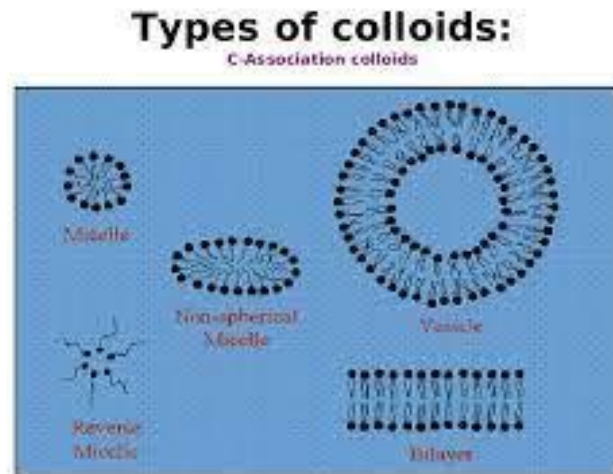


Lyophobic colloids

- ✓ Lyophobic colloids are liquid hating colloids (Lyo means solvent and phobic means hating).
- ✓ When these colloids are mixed with the suitable liquid, very weak force of attraction exists between colloidal particles and liquid and system does not pass into colloidal state readily.
- ✓ Therefore, Lyophobic sols are difficult to prepare.
- ✓ Special techniques are employed to prepare these sols.

Association colloids

Organic compounds that contain large hydrophobic moieties on the same molecule with strongly hydrophilic groups are said to be amphiphilic.

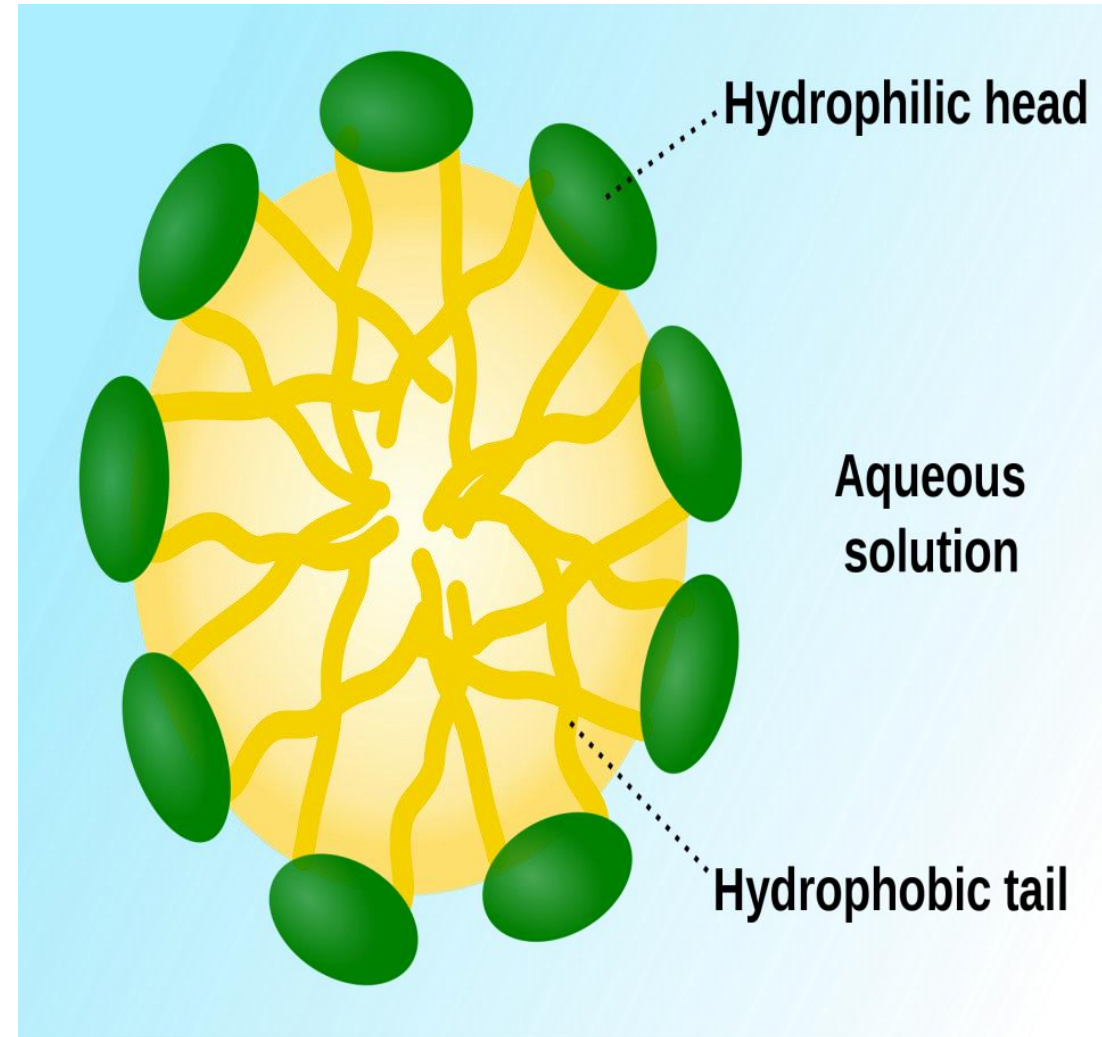


Lyophilic Sols	Lyophobic Sols
<ol style="list-style-type: none"> 1. They can be prepared easily by directly mixing with the liquid dispersion medium. 2. They are quite stable and are not easily get precipitated. 3. They are reversible in nature once precipitated can reform the colloidal sol by simply remixing with dispersion medium. 4. Their surface tension is lower than dispersion medium. 	<ol style="list-style-type: none"> 1. They cannot be prepared directly can be prepared by the special methods only. 2. They can be easily precipitated by addition of a small amount of the electrolyte. 3. They are irreversible in the nature once precipitated cannot form the colloidal sol by simple addition of dispersion medium. 4. Their surface tension is nearly same as the dispersion medium.

Micelles

- ✓ A **micelle** is an aggregate of surfactant molecules dispersed in a liquid colloid.
- ✓ A typical micelle in aqueous solution forms an aggregate with the hydrophilic "head" regions in contact with surrounding solvent, sequestering the hydrophobic single-tail regions in the micelle centre.
- ✓ This phase is caused by the packing behavior of single-tail lipids in a bilayer.
- ✓ The difficulty filling all the volume of the interior of a bilayer, while accommodating the area per head group forced on the molecule by the hydration of the lipid head group, leads to the formation of the micelle.
- ✓ This type of micelle is known as a normal-phase micelle (oil-in-water micelle).
- ✓ Inverse micelles have the head groups at the centre with the tails extending out (water-in-oil micelle).

- ✓ The concentration of monomer at which micelles form is termed the critical micelle concentration(CMC).
- ✓ Examples include surfactant molecules that associate into micelles above their critical micelle concentration (CMC).
- ✓ Micelles are approximately spherical in shape.
- ✓ These aggregates, which may contain 50 or more monomers, are called micelles.
- ✓ Because the diameter of each micelle is of the order of 50 \AA , micelles lie within the size range we have designated as colloidal.
- ✓ The number of monomers that aggregate to form a micelle is known as the aggregation number of the micelle.



Micelles vs Colloidal Particles

More Information Online WWW.DIFFERENCEBETWEEN.COM

Micelles

Colloidal Particles

DEFINITION

Micelles are colloidal particles that form as aggregates of surfactant molecules

Colloidal particles are the particles that are dispersed in a suspension

FORMATION

Due to hydrophilic and hydrophobic effects

Due to insolubility or saturation of the solution

PARTICLES

Surfactant molecules

Can differ according to the dispersion medium; e.g. in milk, colloidal particles are fat globules whereas in blood, colloidal particles are blood cells and proteins

SIZE

Can vary from 2 to 20 nanometers

Can vary from 1 to 1000 nanometers

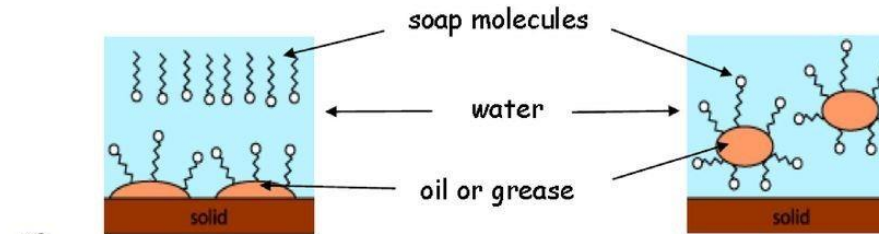
EXAMPLES

Detergents in water

Blood, milk, aerosol, sprays, etc.

Cleansing Action of Soap

Cleaning with water alone has little effect when stains consist of non-polar substances, such as grease and sweat. The structure of soaps allow fats and oils to break away from the fabric and disperse in water. During cleaning, the **hydrophobic tails dissolve in a droplet of oil or grease**, whilst the **hydrophilic heads face out into the surrounding water** resulting in ball-like structure. With agitation or scrubbing the grease becomes dislodged from the surface and further soap ions attach themselves. The non-polar substances, such as oil and grease, are held inside the ball and suspended in the water.



DISCUSS

After discussion with your teacher and others can you explain how soaps work?

Biological Importance of Colloids

Biological fluids as colloids

Blood, Milk, cerebrospinal fluids are the part of it.

Biological compounds as colloidal particles

The complex molecule of life, the high molecular weight proteins complex lipids and polysaccharides exist in colloidal state.

Blood Coagulation

When blood clotting occurs, the sol is converted finally into gel.

Fat digestion and Absorption

The formation of emulsions, facilitated by the emulsifying agents bile salts, promotes fat digestion and absorption in the intestinal tract. is a colloidal solution and is negatively charged.

Formation of Urine

The filtration of urine based on the principle of dialysis.

Applications of colloidal solutions:

1- Therapy--- Colloidal system are used as therapeutic agents in different areas.

e.g- Silver colloid-germicidal
Copper colloid-anticancer
Mercury colloid-Antisypilis

2- Stability---e.g. lyophobic colloids prevent flocculation in suspensions.

e.g- Colloidal dispersion of gelatin is used in coating over tablets and granules which upon drying leaves a uniform dry film over them and protect them from adverse conditions of the atmosphere.

3- Absorption--- As colloidal dimensions are small enough, they have a huge surface area. Hence, the drug constituted colloidal form is released in large amount.

e.g- sulphur colloid gives a large quantity of sulphur and this often leads to sulphur toxicity

4-Targeted Drug Delivery--- Liposomes are of colloidal dimensions and are preferentially taken up by the liver and spleen.

5- Photography:-----A colloidal solution of silver bromide in gelatine is applied on glass plates or celluloid films to form sensitive plates in photography.

6- Clotting of blood:----- Blood is a colloidal solution and is negatively charged.

On applying a solution of FeCl_3 bleeding stops and blood clotting occurs as Fe^{+3} ions neutralize the ion charges on the colloidal particles.

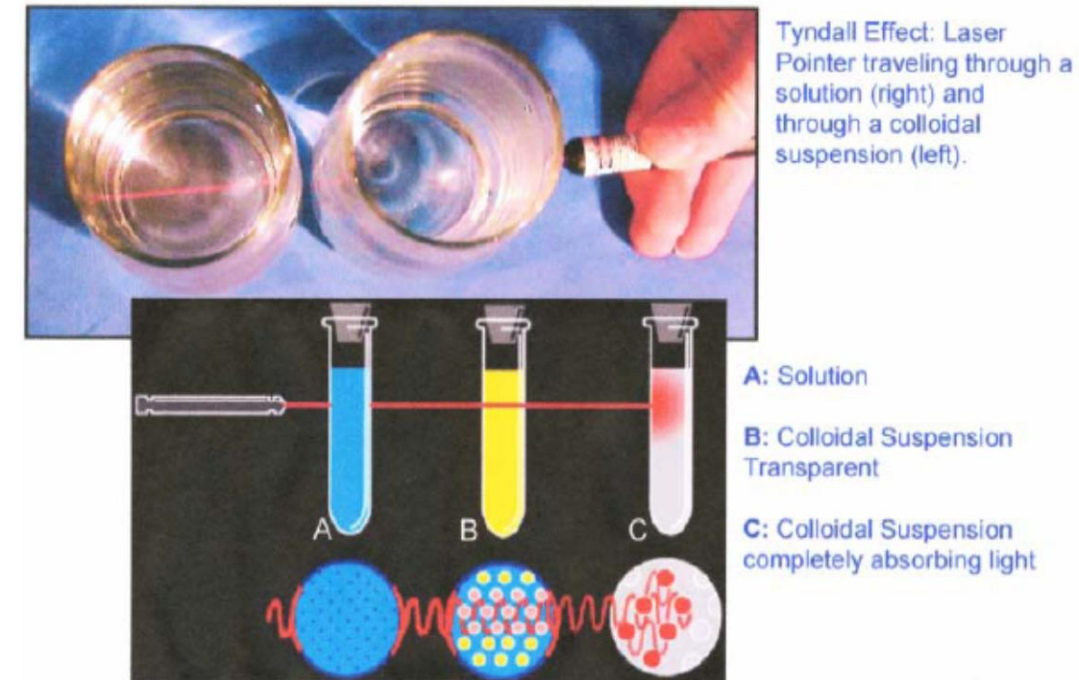
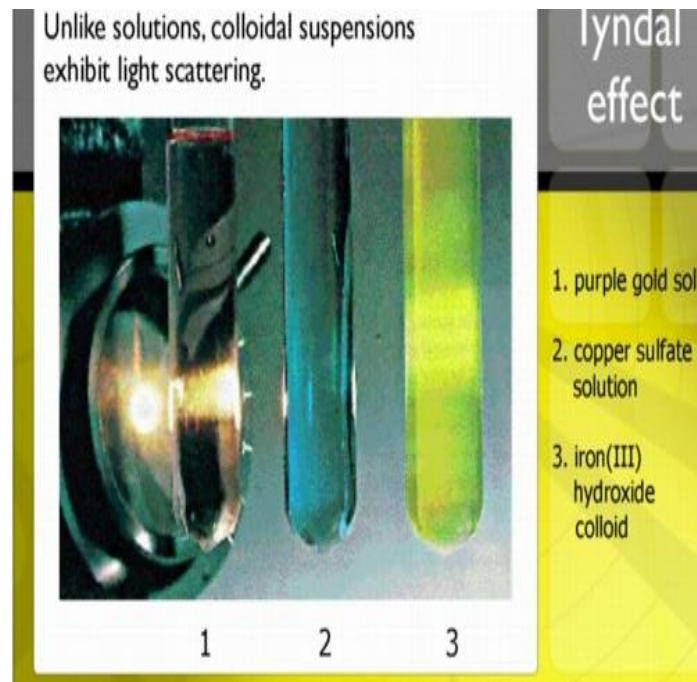
Applications of colloids

- ✓ **Food and medicines**: Colloids have great application in food industries and food stuffs. Many of the food materials which we eat are of colloidal nature. Milk and also many milk products like cheese, cream butter etc. are colloids.
- ✓ **Water Purification**: We know that one of the very popular methods used for water purification is the addition of electrolytes like potash alum. Addition of these electrolytes is based on the fact because the impure water is usually a colloidal system. It usually contains dispersed colloidal particles which cannot be removed by filtration. Addition of these electrolytes results in coagulation of the impurity which can be separated by filtration then.
- ✓ **Sewage disposal**: As discussed above the sewage water contains impurities like mud and dirt of colloidal size which are dispersed in the water. Just like any other colloidal system, the colloidal particles (impurities) of sewage are also charged particles. These charged particles of impurities present in sewage may be removed by electrophoresis.
- ✓ **Smoke precipitation**: Smoke is also a colloidal system which mainly consists of charged particles of carbon deposited in air.
Smoke is a big problem for environment as it is the major source for air pollution.
Removal of the dispersed colloidal particles from the air will solve the problem. For this again the process of electrophoresis is used.

Optical Properties of Colloids

1-Faraday-Tyndall effect

- ✓ When a strong beam of light is passed through a colloidal sol, the path of light is illuminated (a visible cone formed).
- ✓ This phenomenon resulting from the scattering of light by the colloidal particles.
- ✓ The same effect is noticed when a beam of sunlight enters a dark room through a slit when the beam of light becomes visible through the room.
- ✓ This happens due to the scattering of light by particles of dust in the air.
- ✓ Turbidity: the fractional decrease in intensity due to scattering as the incident light passes through 1 cm of solution.
- ✓ Scattering described in terms of turbidity, T
- ✓ Turbidity is proportional to the molecular weight of lyophilic colloid



$$H_c / T = 1/M + 2Bc$$

T: turbidity

C: conc of solute in gm / cc of solution

M: molecular weight

B: interaction constant

H: constant for a particular system

2- Electron microscope

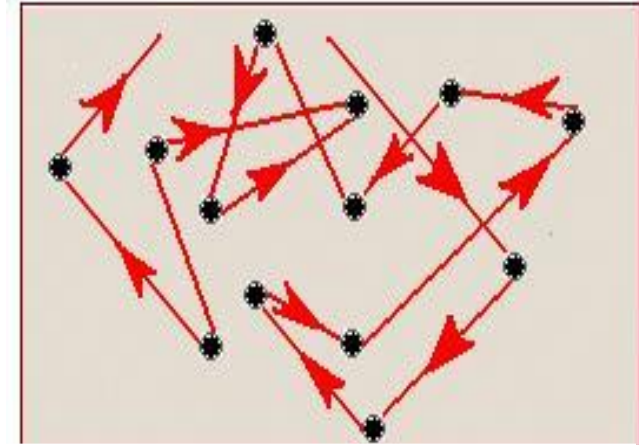
- ✓ Ultra-microscope has declined in recent years as it does not able to resolve lyophilic colloids.
- ✓ so electron microscope is capable of yielding pictures of actual particles size, shape and structure of colloidal particles.
- ✓ Electron microscope has high resolving power, as its radiation source is a beam of high energy electrons, while that of optical microscope is visible light.



Kinetic Properties of Colloids

1-Brownian motion

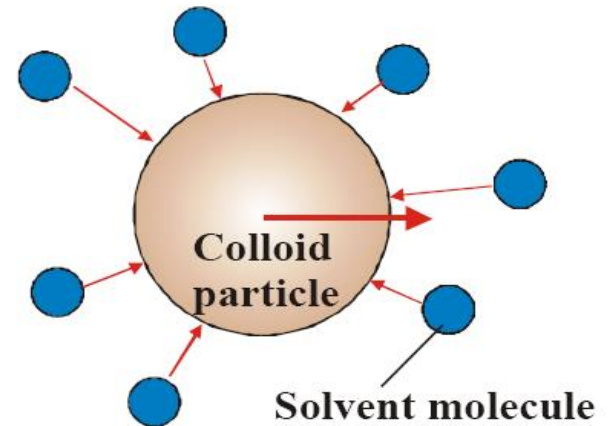
- ✓ The zig-zag movement of colloidal particles continuously and randomly.
- ✓ This brownian motion arises due to the uneven distribution of the collisions between colloid particle and the solvent molecules.
- ✓ Brownian movement was more rapid for smaller particles.
- ✓ It decrease with increase the viscosity of the medium.



2-Osmotic pressure

- van 't hof equation:
 $\pi = cRT$ (π = osmotic pressure, R= molar gas constant)
- Can be used to determine the molecular weight of colloid in dilute solution.
- Replacing c by C / M (where C = the grams of solute / liter of solution, M = molecular weight)

$$\pi/C = RT/M$$



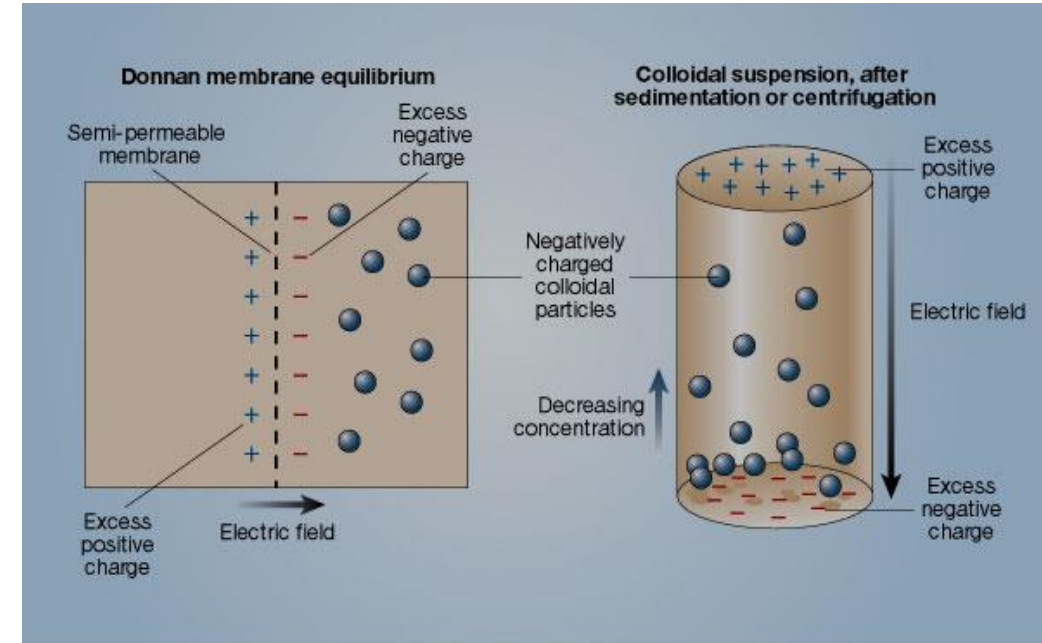
3- Non-dialyzable nature

The particles large in size cannot pass through membrane. However membrane allows dispersion medium, so smaller particles can escape through the pores. The process known as dialysis and usefull for separation of colloids.

4- donnan membrane equilibrium (Sedimentation Potential)

The presence of non-diffusible colloidal particles in the biological system influence the concentration of diffusible ions across the membrane.

- ✓ It is the potential induced by the fall of a charged particle under an external force field.
- ✓ It is analogous to electrophoresis in the sense that a local electric field is induced as a result of its motion.
- ✓ if a colloidal suspension has a gradient of concentration (such as is produced in sedimentation or centrifugation), then a macroscopic electric field is generated by the charge imbalance appearing at the top and bottom of the sample column.



5- Electric Properties Of Colloids

The particles of a colloidal solution are electrically charged and carry the same type of charge, either negative or positive.

The colloidal particles therefore repel each other and do not cluster together to settle down.

The charge on colloidal particles arises because of the dissociation of the molecular electrolyte on the surface.

E.g. As_2S_3 has a negative charge

During preparation of colloidal As_2S_3 , H_2S is absorbed on the surface and dissociate to H^+ (lost to the medium) and S^{2-} remain on the surface of colloid.

$\text{Fe}(\text{OH})_3$ is positively charged

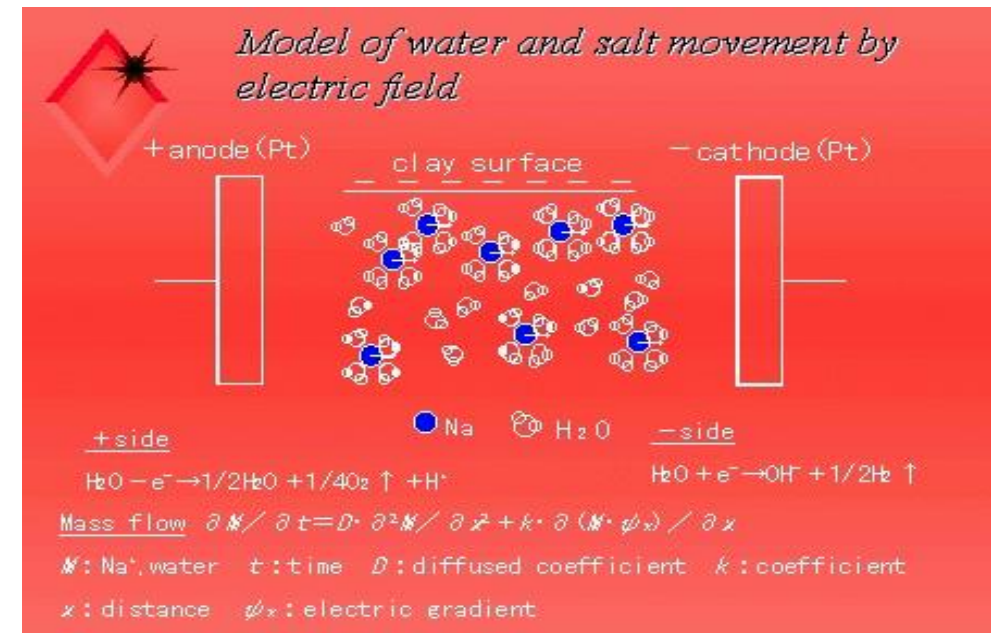
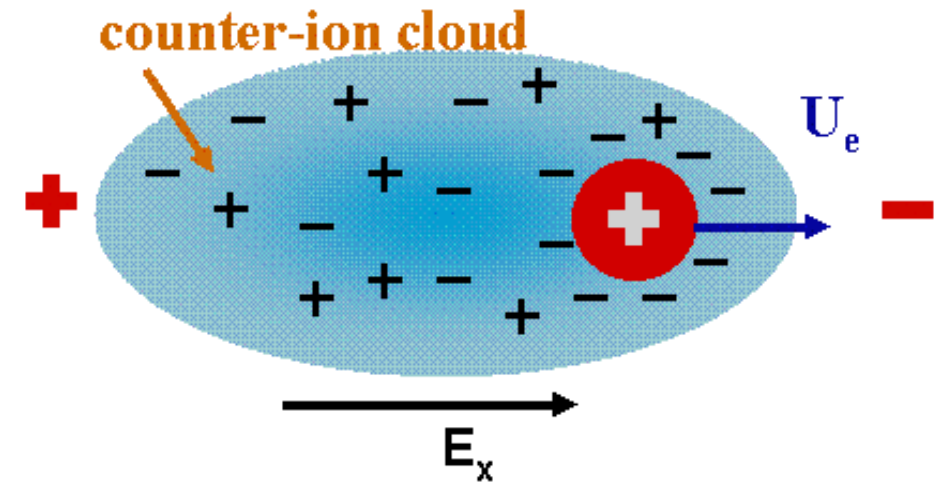
Due to self dissociation and loss of OH^- to the medium, so they become $[\text{Fe}(\text{OH})_3] \text{Fe}^{+3}$

Electrophoresis

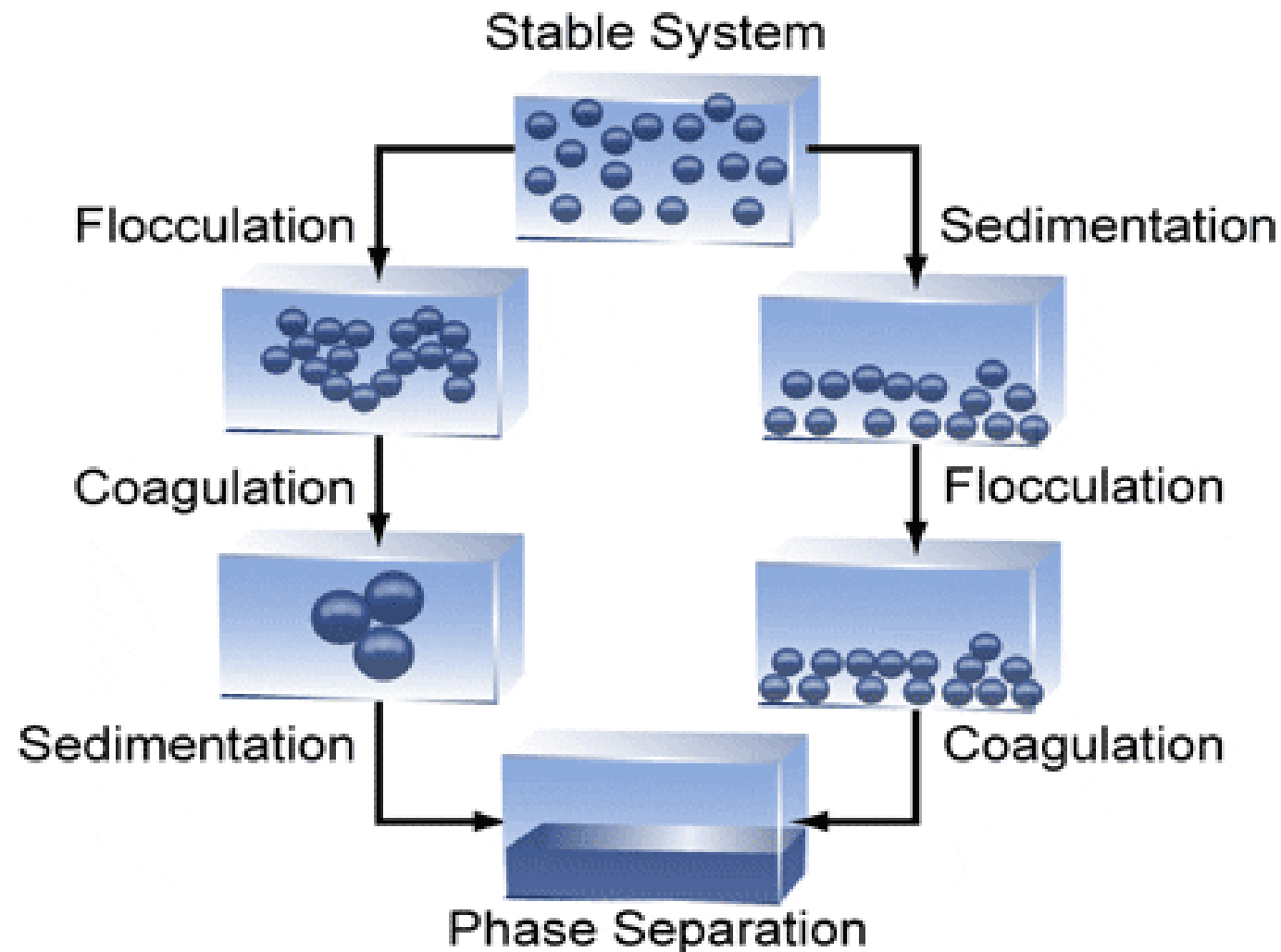
- ✓ Electrophoresis is the most known electrokinetic phenomena. It refers to the motion of charged particles related to the fluid under the influence of an applied electric field.
- ✓ If an electric potential is applied to a colloid, the charged colloidal particles move toward the oppositely charged electrode.

Electro-osmosis

- ✓ It is the opposite in principal to that of electrophoresis.
- ✓ When electrodes are placed across a clay mass and a direct current is applied, water in the clay pore space is transported to the cathodically charged electrode by electro-osmosis.
- ✓ Electro-osmotic transport of water through a clay is a result of diffuse double layer cations in the clay pores being attracted to a negatively charged electrode or cathode. As these cations move toward the cathode, they bring with them water molecules that clump around the cations as a consequence of their dipolar nature.

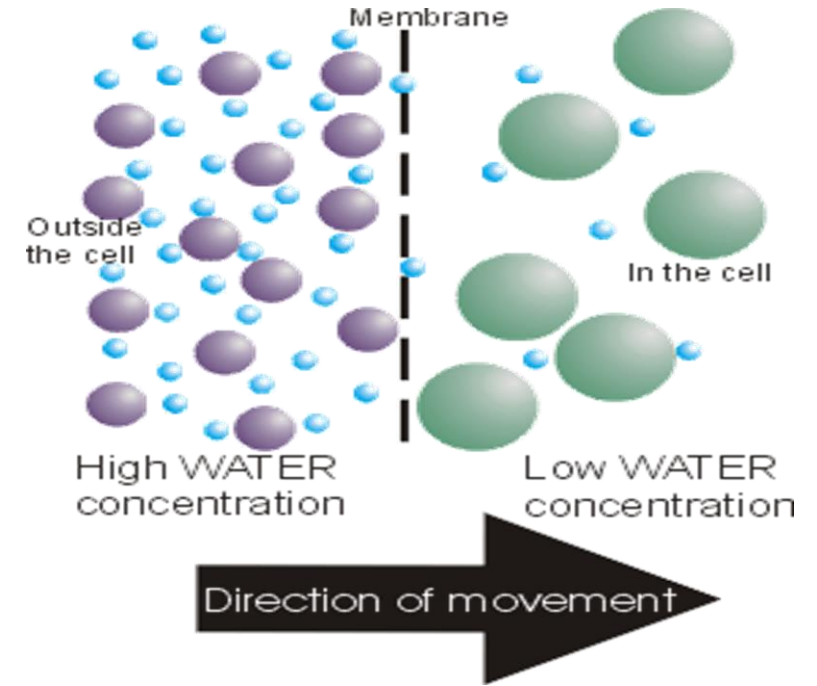


Stability of colloids



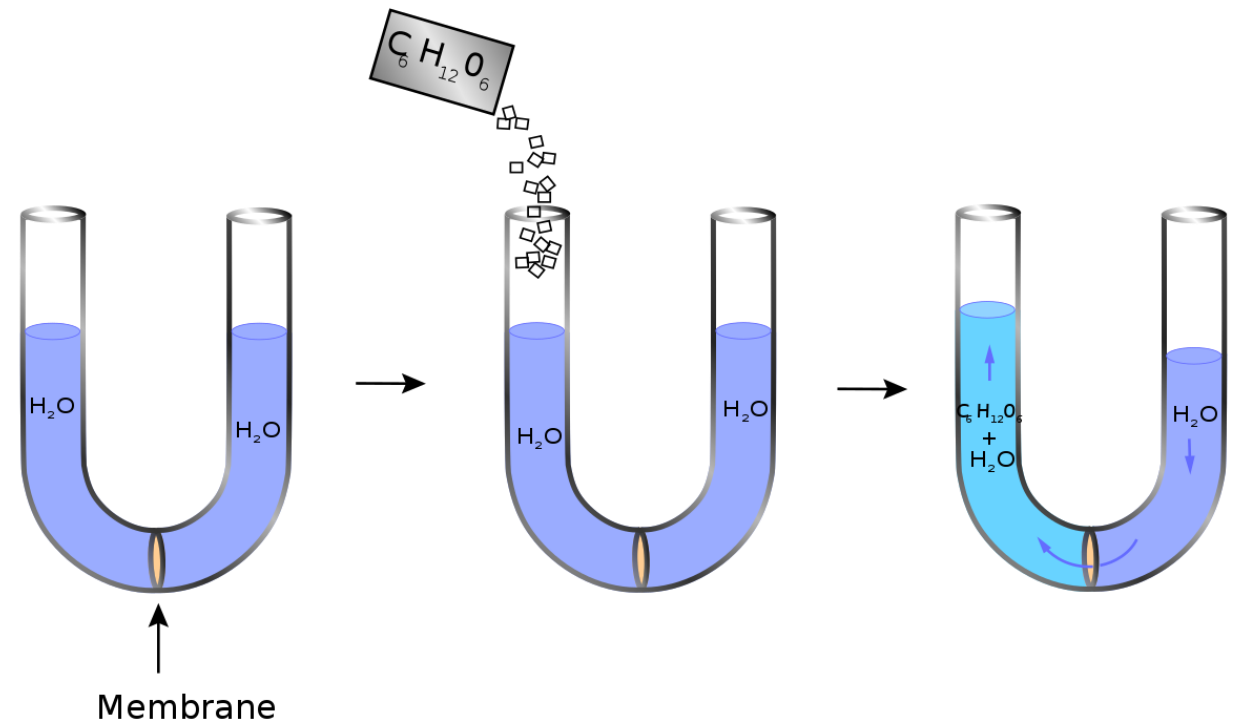
Osmosis

- ✓ Osmosis is the movement of **WATER** across a semi-permeable membrane
- ✓ The flow of solvent occurs from a solution of low concentration to the solution of high concentration, when both are separated by semipermeable membrane.
- ✓ Semipermeable membrane is expected to be permeable to the solvent to the solvent and not to the solute.
- ✓ At first the concentration of solute is very high on the left.
- ✓ But over time, the water moves across the semi-permeable membrane and dilutes the particles.

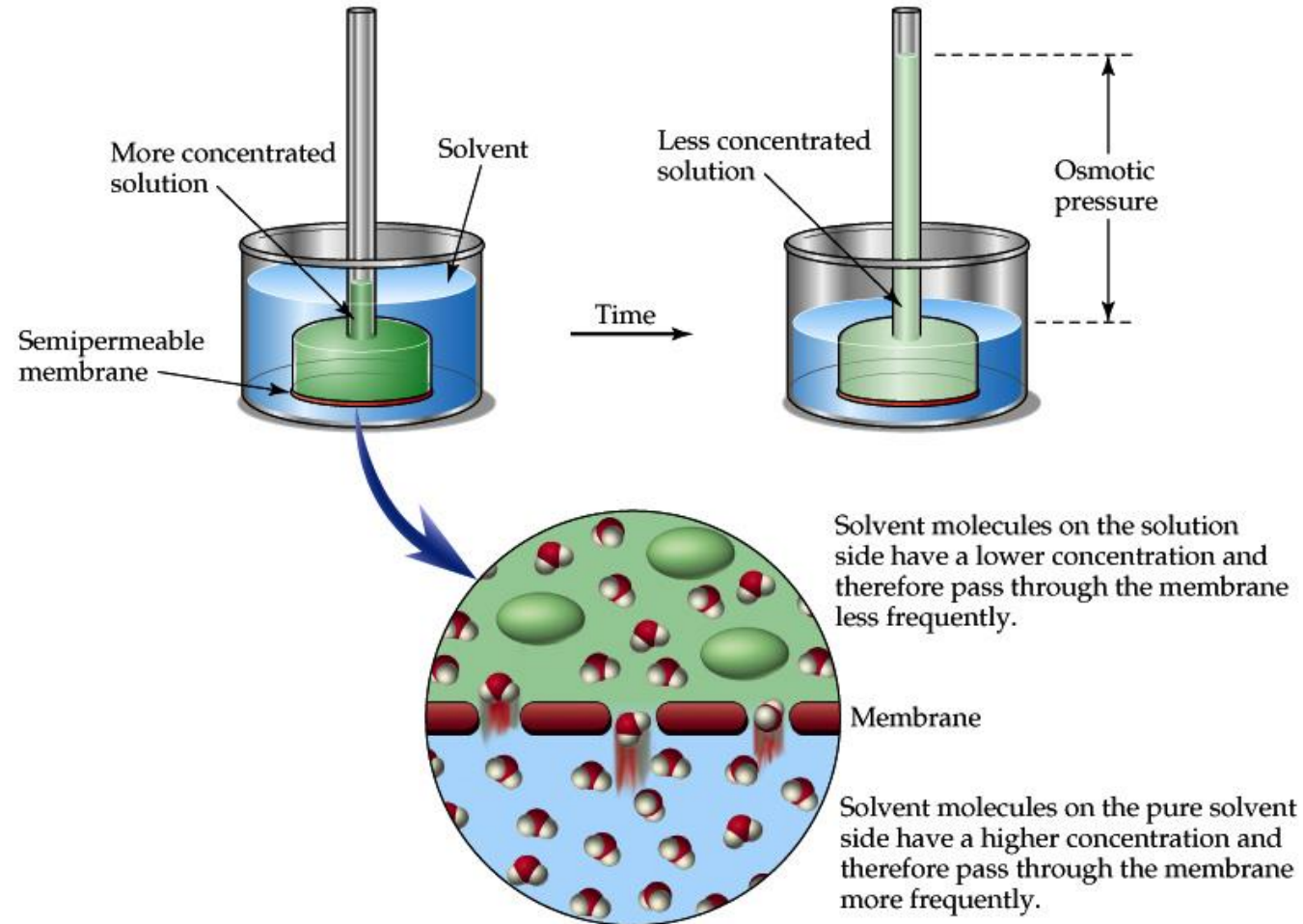


Osmotic Pressure

- ✓ Osmotic pressure is the minimum pressure which needs to be applied to a solution to prevent the inward flow of its pure solvent across a semipermeable membrane.
- ✓ It is also defined as the measure of the tendency of a solution to take in a pure solvent by osmosis.
- ✓ Potential osmotic pressure is the maximum osmotic pressure that could develop in a solution if it were separated from its pure solvent by a semipermeable membrane.
- ✓ The term oncotic pressure is commonly used to represent the osmotic pressure of colloidal substance (Albumin, Globulin).



Osmosis and Osmotic Pressure

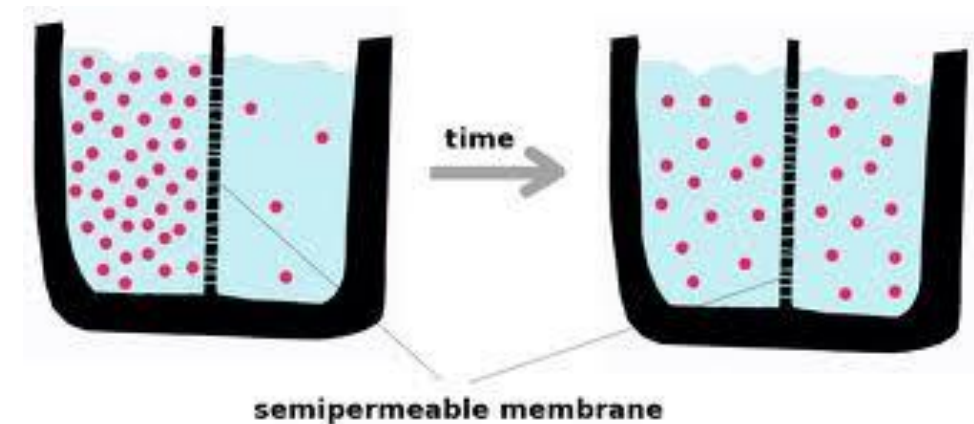
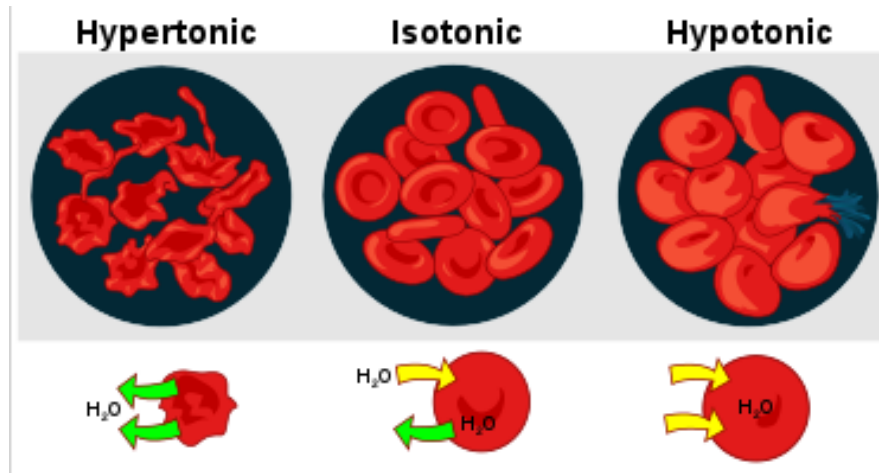
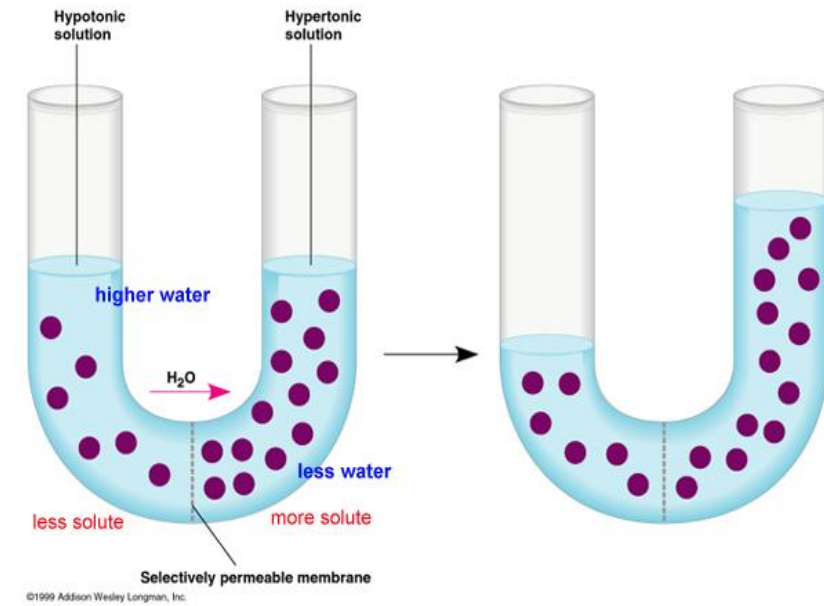


Types of osmosis

Hypotonic – The solution on one side of a membrane where the solute concentration is less than on the other side. Hypotonic Solutions contain a low concentration of solute relative to another solution.

Hypertonic – The solution on one side of a membrane where the solute concentration is greater than on the other side. Hypertonic Solutions contain a high concentration of solute relative to another solution.

Isotonic -Over time molecules will move across the membrane until the concentration of solutes is equal on both sides. This type of solution is called Isotonic. The solution that exert the same osmotic pressure are said to be Isoosmotic.



Unit of Osmotic Pressure

- ✓ Osmole is the unit of osmotic pressure
- ✓ One Osmole is the number of molecules in gram molecular weight of un-dissociated solute.
- ✓ For Example:
- ✓ One gram molecular weight of glucose (180 g) is 1 osmole.
- ✓ One gram molecular weight of NaCl (58.5) is equivalent to 2 osmoles, since NaCl ionizes to give two particles (Na^+ , Cl^-).
- ✓ Osmotic pressure of biological fluids is expressed in milliosmoles. i.e. Plasma is 280—300 milliosmoles/Liter.

Colligative Property

It is defined as a character which depends upon the number of solute particles but not on their nature.

Osmotic pressure is directly proportional to the concentration (number) of the solute molecules or ions.

That means lower molecular weight (NaCl, Glucose) will have more number of molecules compared to high molecular weight substances (albumin, globulin) for unit mass.

Substance with lower molecular weight exhibits greater osmotic pressure.

For ionizable compounds

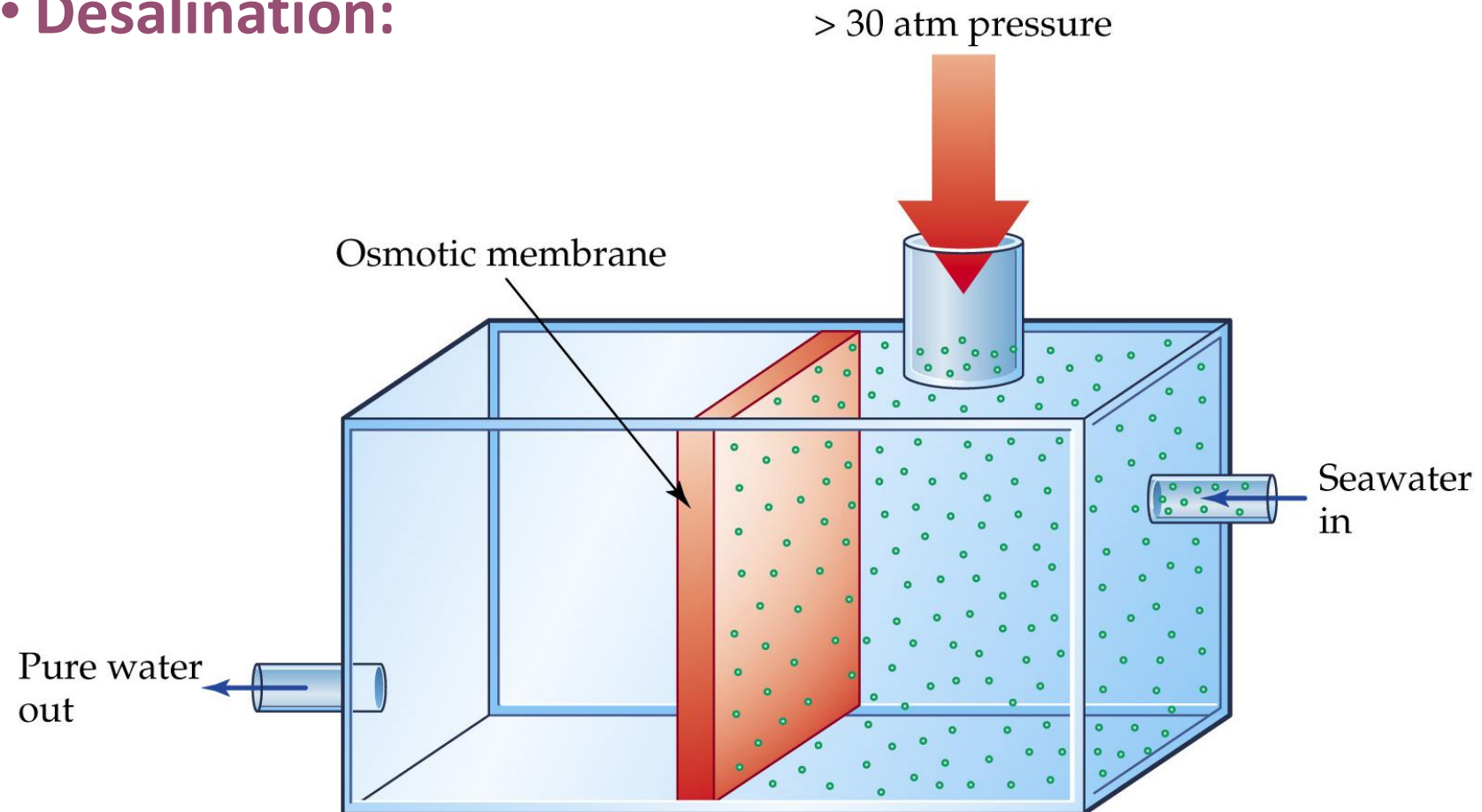
The total osmotic pressure is equivalent to the sum of the individual pressures exerted by each ion.

i.e. One molar solution of NaCl will exert double the osmotic pressure of one molar solution of glucose.

Because NaCl ionizes into Na^+ and Cl^- while glucose is non-ionizable.

Uses of Colligative Properties

- **Desalination:**



Applications of Osmosis

1- Fluid balance and Blood Volume

- ✓ It is responsible to maintain fluid balance of different compartment in body.
- ✓ It also contributes to the regulation of blood volume and urine excretion.

2- Red blood cells and fragility

- ✓ The intracellular fluid of erythrocytes is a solution of salts, glucose, protein and hemoglobin. A 0.9% NaCl solution is said to be isotonic: when blood cells reside in such a medium, the intracellular and extracellular fluids are in osmotic equilibrium across the cell membrane, and there is no net influx or efflux of water.
- ✓ When subjected to hypertonic media (e.g. 1.8% NaCl), the cells lose their normal biconcave shape, undergoing collapse (leading to crenation) due to the rapid osmotic efflux of water.
- ✓ On the other hand, in a hypotonic environment (e.g. 0.4% NaCl or distilled water), an influx of water occurs: the cells swell, the integrity of their membranes is disrupted, allowing the escape of their hemoglobin (hemolysis) which dissolves in the external medium.

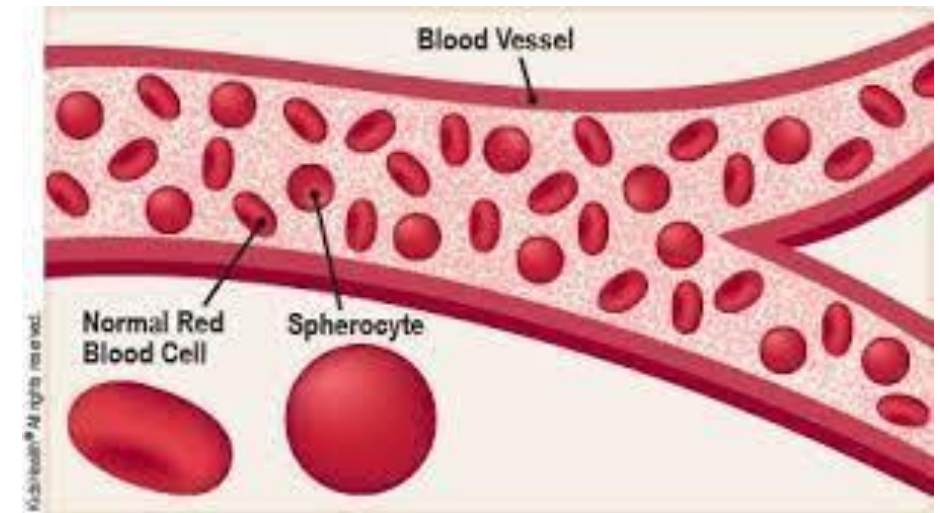
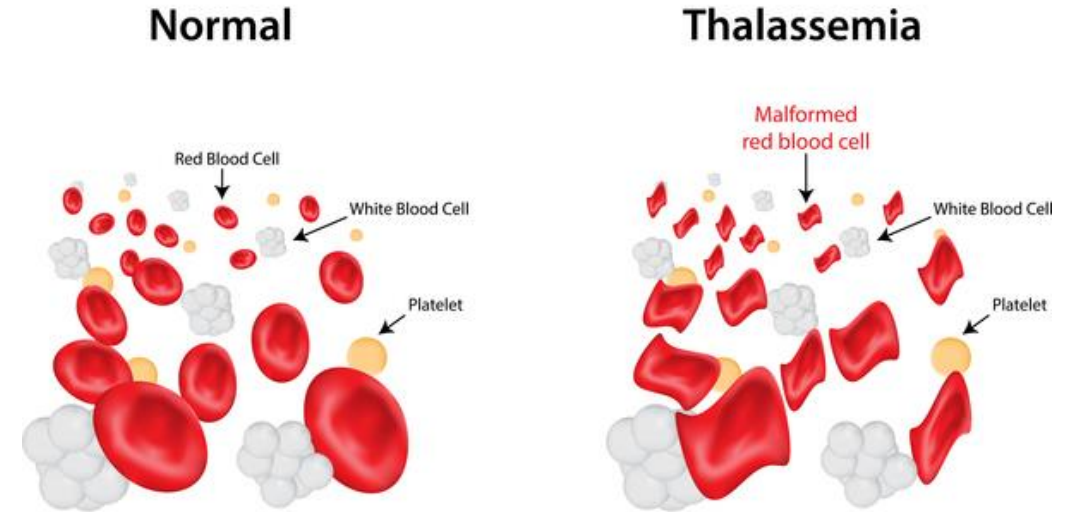
3- Osmotic fragility test

- ✓ This test is employed in laboratories for the diagnosis purpose regarding RBC.
- ✓ In Normal Human RBC begin to hemolyse in 0.45% NaCl, and it complete at 0.33% NaCl.
- ✓ Increased frangility of RBC is observed in hemolytic jaundice while its is decreased in certain anemias.

Thalassemia causes your body to make an abnormal form of hemoglobin. Hemoglobin is the protein that allows red blood cells to carry oxygen. If you have thalassemia, your red blood cells are more likely to be destroyed. This can lead to anemia.

Hereditary spherocytosis causes problems with the outer layer of your red blood cells, distorting their shape. This leads to more fragile red blood cells and early destruction, which can also cause anemia.

Thalassemia



4- Transfusion

Isotonic solution of NaCl (0.9%) and Glucose 5% or a suitable combination of these two can be used in transfusion in hospital for the treatment of dehydrations and burn etc.

5- Actions of Purgatives

The mechanism of action of purgatives is mainly due to the osmotic phenomenon.

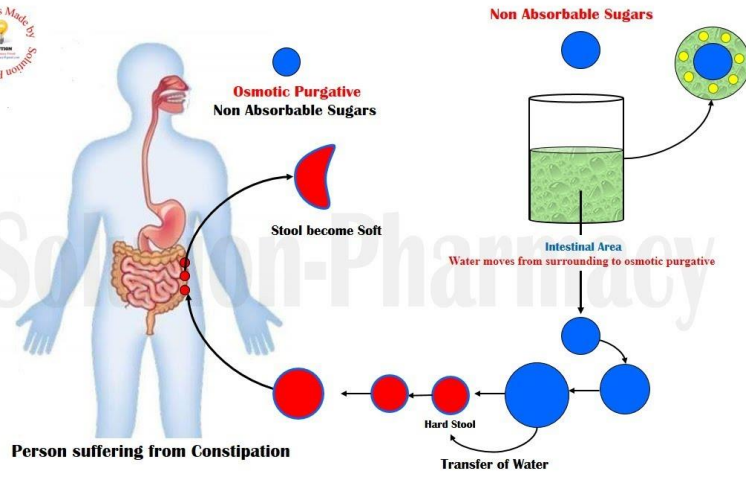
For instance Epson ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) and Glauber's ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) withdraw water from the body, beside preventing intestinal water absorption.

3.Management of dehydration and burns



ISOTONIC FLUIDS AND THEIR USES:

0.9% NaCl	Lactated Ringers'	D5W
<ul style="list-style-type: none">•Shock•Resuscitation•Fluid challenges•Blood transfusions•Metabolic alkalosis•Hyponatremia•DKA <p>•Use with caution in patients with heart failure, edema, or hypernatremia.</p> <p>•Can lead to fluid overload.</p>	<ul style="list-style-type: none">•Dehydration•Burns•GI tract fluid loss•Acute blood loss•Hypovolemia <p>•Contains potassium, can cause hyperkalemia in renal patients.</p> <p>Patients with liver disease cannot metabolize lactate.</p> <p>Lactate is converted into bicarb by liver.</p>	<ul style="list-style-type: none">•Fluid loss and dehydration•Hypernatremia <p>•Solution becomes hypotonic when dextrose is metabolized</p> <p>•Do not use for resuscitation</p> <p>•Use cautiously in renal and cardiac patients</p>



MECHANISM OF ACTION

All purgatives increase the water content of the faeces by:

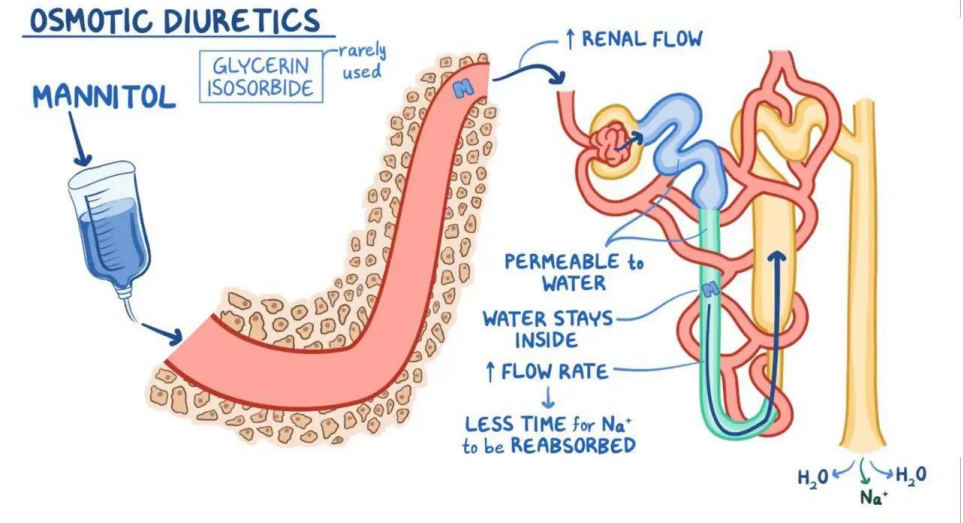
- A hydrophilic or osmotic action, **retaining water and electrolytes in the intestinal lumen**—increase volume of colonic content and make it easily propelled.
- Acting on intestinal mucosa, **decrease net absorption of water and electrolyte**; intestinal transit is enhanced indirectly by the fluid bulk.
- Increasing propulsive activity** as primary action—allowing less time for absorption of salt and water as a secondary effect.

6-Osmotic Diuresis

The high blood glucose concentration causes osmotic diuresis resulting in the loss of water electrolytes and glucose in the urine.

This is the basis of polyuria observed in the Diabetic Mellitus.

Diuresis can be produced by administering compounds (e.g. mannitol) which are filtered but not reabsorbed by renal tubules.



7- Edema due to hypoalbuminemia

Disorder such as kwashiorkor and glomerulonephritis are associated with lowered plasma albumin concentration and edema. Edema is caused by reproduced oncotic pressure of plasma, leading to the accumulation of excess in tissue spaces.

Specific Symptoms

Hypertension

- High blood pressure

Eyes

- Conjunctivitis

Kidney Disease

- Oliguria
- Proteinuria

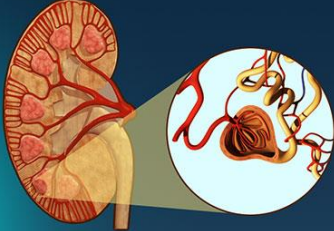
Central Nervous System

- Mononeuritis multiplex

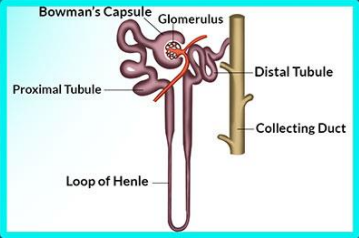
Nail

- Discoloration of nail

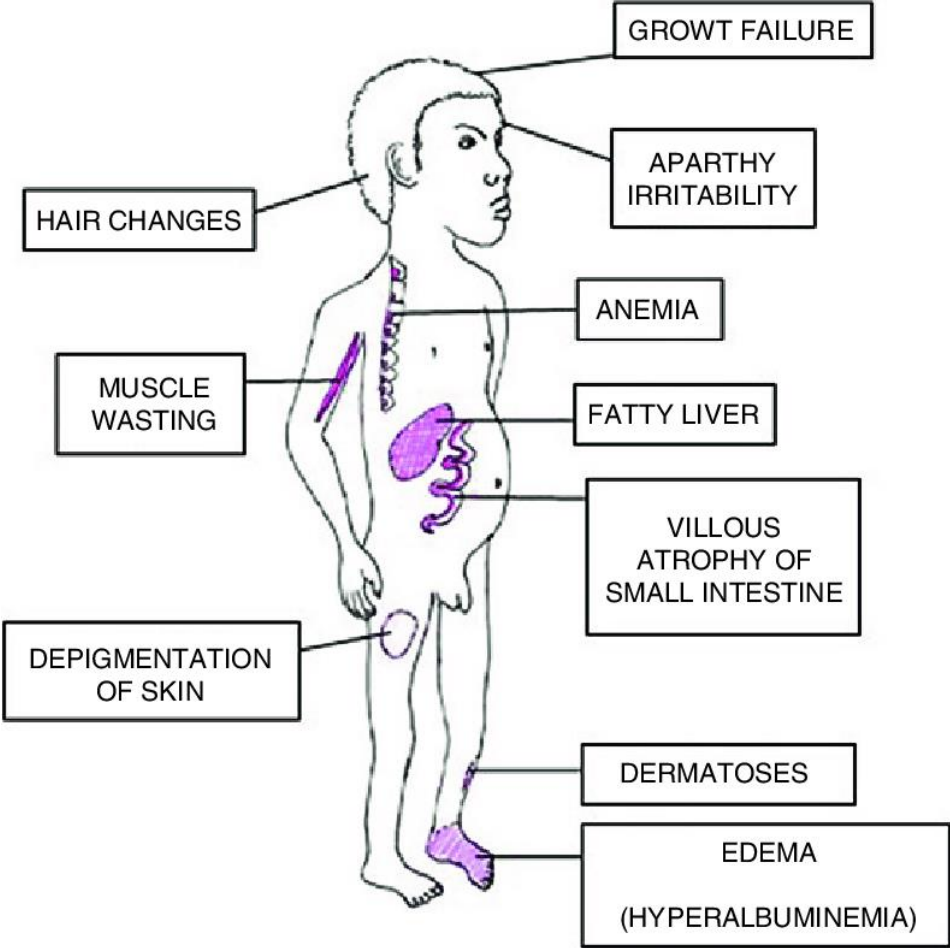
Rapidly Progressive Glomerulonephritis



Glomerulonephritis



For More Information Visit: www.ePainAssist.com



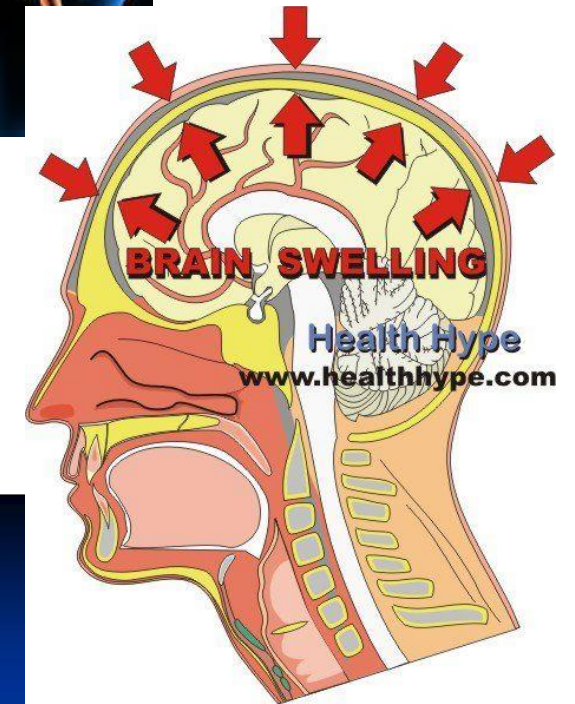
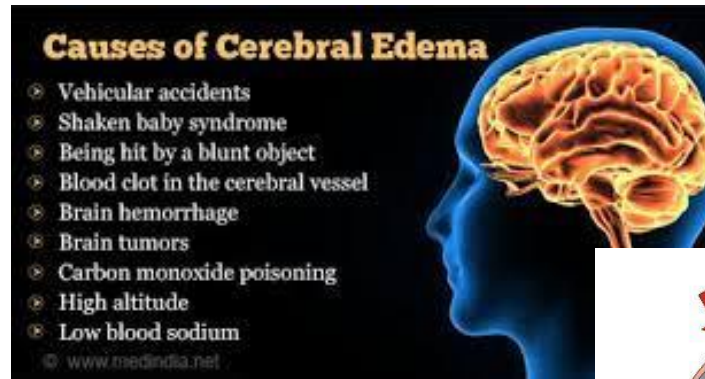
8- Cerebral Edema

Hypertonic solution of salts (NaCl , MgSO_4) are in use to reduce the volume of the brain of the pressure of cerebrospinal fluid.

9- Irrigation of wounds

Isotonic solutions are used for washing wounds.

The pain experienced by the direct addition of salts or sugar to wounds is due to osmotic removal of water.



Wound Irrigation

- Volume
- Delivery Method
 - high or low pressure
 - pulsatile or continuous
- Choice of Solution
 - Antiseptics
 - Antibiotics
 - detergents



Viscosity

- ✓ Why do some liquids flow more slowly than others? (oil vs water) (Viscosity in Liquids)
- ✓ Because some particles can move around, but it may be difficult for them to pass by each other.



Viscosity in liquids

- ✓ Viscosity can be defined as the **resistance to flow**.
- I.e. Water flows easier than oil because water particles slip past each other more easily than oil particles do past one another – stronger bonds between oil particles!!
- So: oil has higher resistance to flow = higher viscosity

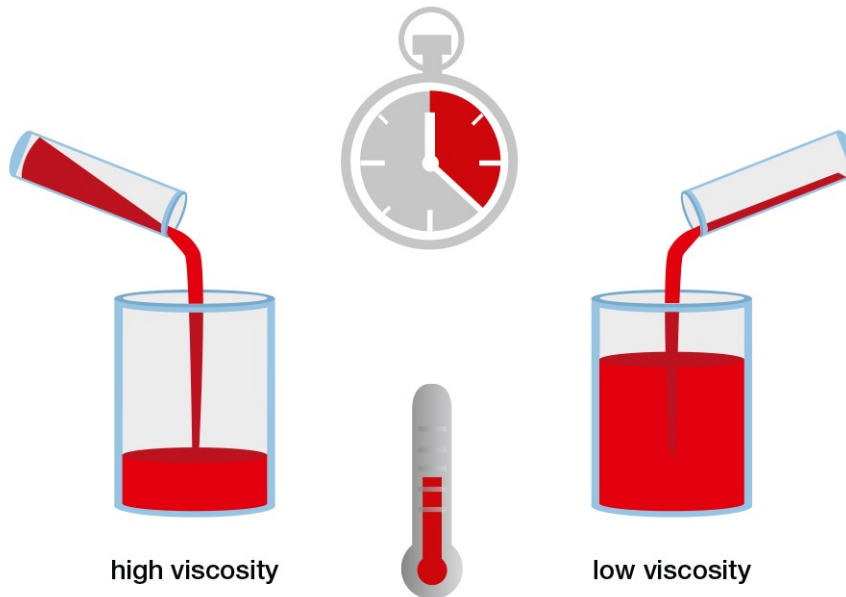


Temperature Effects

✓ So,

↑ Temp = ↓ forces between particles
↓ forces = less resistance to flow
= higher flow rate
= lower viscosity

↓ Temp = ↑ forces between particles
↑ forces = more resistance to flow
= lower flow rate
= higher viscosity



Viscosity in Gases

- ✓ In gases, particles are so far apart and attractive forces are very low

So, particles of gas are more likely to collide than rub up against one another!

How can the internal friction of a gas be affected?

- ✓ When a constricted gas flows, it moves in one direction

ie. Air flowing out of a balloon or air out of a tire

If the gas particles have low enough energy so that most are moving in the same direction, then the viscosity will be low...

- ✓ But, as the particles gain energy, the motion increases in all directions, which increases the number of collisions.
- ✓ Therefore, internal friction is increased and it won't flow as well.

Temperature Effects

- ✓ So, as the temperature increases, gas particles gain energy and move faster and the number of collisions increases

↑ Temp = ↑ viscosity

↓ Temp = ↓ viscosity

(The exact opposite of liquids!!!!)

Applications of Viscosity

1. Viscosity in blood

- ✓ It is time more viscus than water.
- ✓ it is because of suspended blood cells and colloidal plasma protein.
- ✓ Due to blood flow though capillaries viscosity decrease to facilitate free flow of blood.
- ✓ Viscosity of blood is increased in polycythemia (elevation of RBC), while reduce in anemia and nephritis.
- ✓ During dehydration viscosity of blood increased, more viscous blood will cause cardiac work load.

2. Viscosity change in Muscle

- ✓ Excitation of muscle is associated with increase in the viscosity of the muscle fibre.
- ✓ This delay the change in the tension of the contracting muscles.

3. Vitreous Body

- ✓ This is an amorphous viscous body located in the posterior chamber of the eye.
- ✓ It is rich is albumin and hyaluronic acid.

4. Synovial fluid

- ✓ It contain hyaluronic acid, which imparts viscosity and help in the lubricating functions of joints

APPLICATION OF VISCOSITY :-

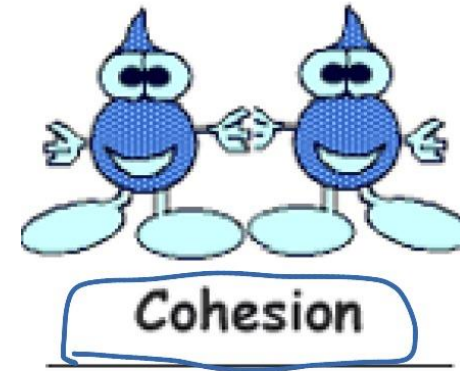
1. Transparent and storing facilities for fluids ie, pipes, tanks
2. Bitumen used for road construction.
3. Designing of the sewer line or any other pipe flow viscosity play an important role in finding out its flow behaviour.
4. Drilling for oil and gas requires sensitive viscosity.
5. To maintain the performance of machine and automobiles by determining thickness of lubricating oil or motor oil.

Application

- ❖ Measure viscosity of dental materials .
- ❖ Materials manipulated in fluid state in oral cavity i.e, materials like cements and impression materials undergo a liquid to solid transformation in mouth.
- ❖ Gypsum products used in fabrication of dies are transformed from slurries into solid structures.
- ❖ Cements used as luting agents and bases...

Surface Tension

- ✓ **Surface tension** is the elastic tendency of a fluid surface which makes it acquire the least surface area possible.
- ✓ At liquid–air interfaces, surface tension results from the greater attraction of liquid molecules to each other (due to cohesion) than to the molecules in the air (due to adhesion).
- ✓ The net effect is an inward force at its surface that causes the liquid to behave as if its surface were covered with a stretched elastic membrane. Thus, the surface becomes under tension from the imbalanced forces, which is probably where the term "surface tension" came from.
- ✓ Surface tension allows insects (e.g. water striders), usually denser than water, to float and stride on a water surface.



Water sticking to water.



Water is sticking to other substances

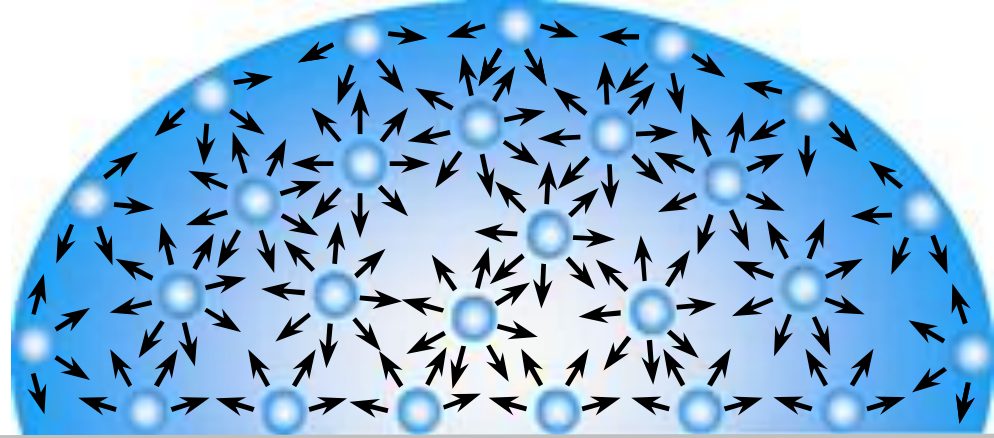


(a) Fig Water beading On a leaf



(b) Fig Water strider walking on the water surface

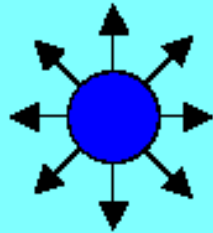
Surface Tension



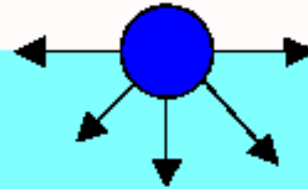
Surface of any liquid
behaves as though it is
covered by a stretched
membrane

F_T

$$\Sigma \mathbf{F} = 0$$

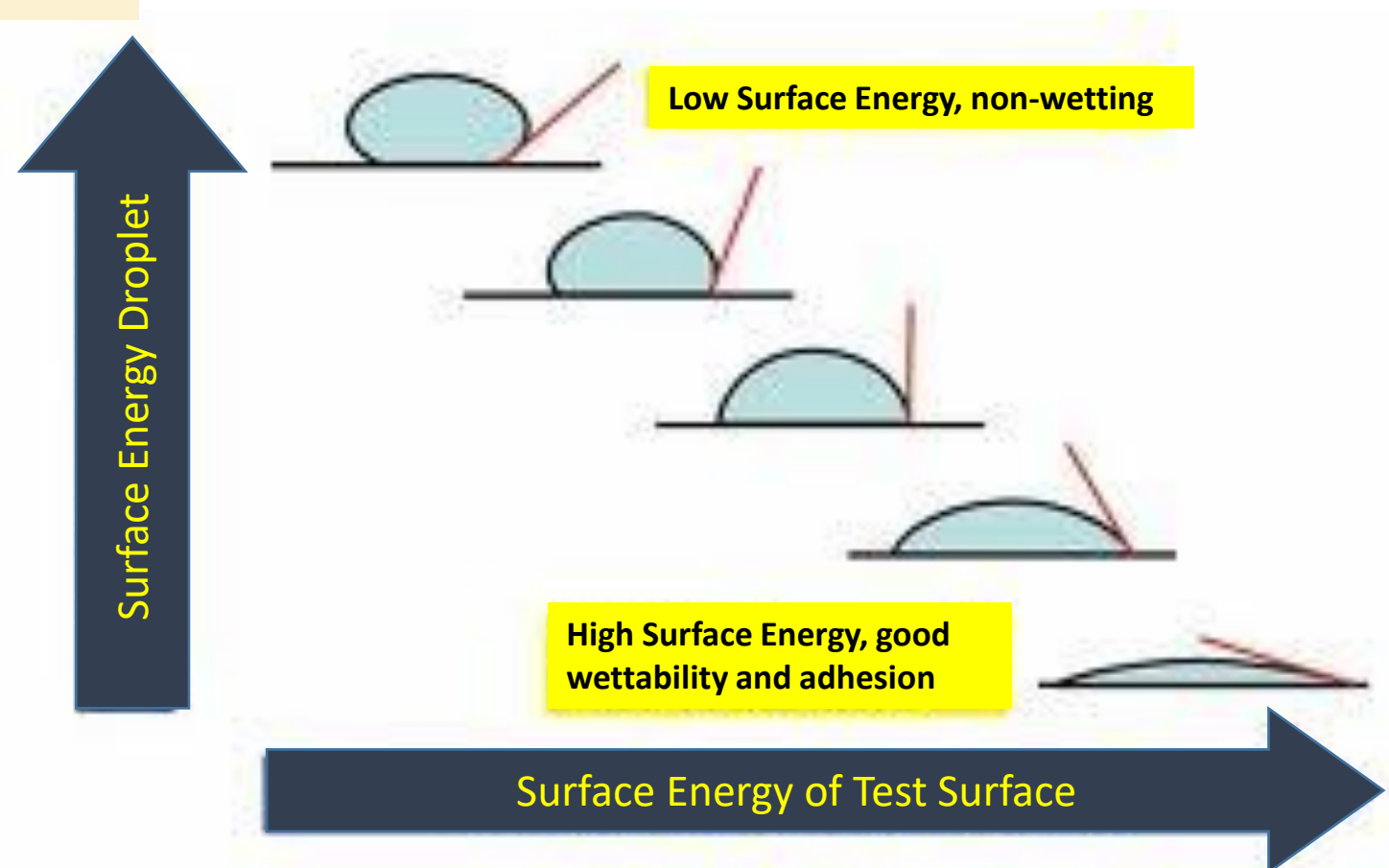
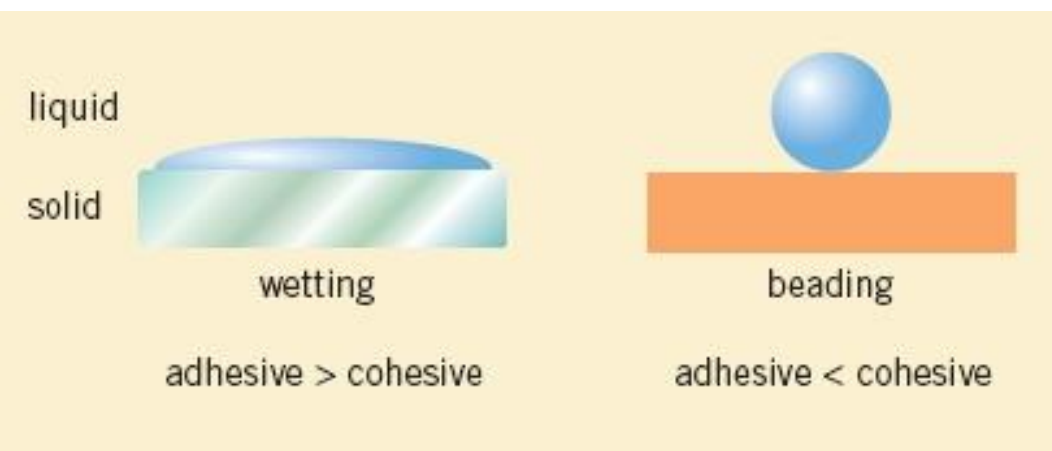


Net force on molecule
at surface is into bulk of the liquid



$\Sigma \mathbf{F}$





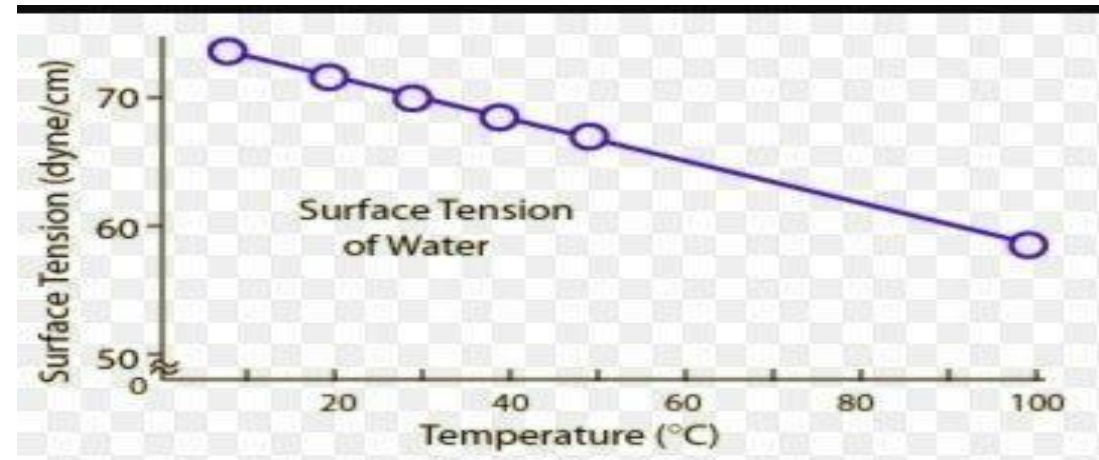
Factors affecting surface tension:

- ✓ Impurities present in a liquid appreciably affect surface tension. A highly soluble substance like salt increases the surface tension whereas sparingly soluble substances like soap decreases the surface tension.
- ✓ The surface tension decreases with rise in temperature. The temperature at which the surface tension of a liquid becomes zero is called critical temperature of the liquid.

Effect of temperature :

- ✓ Oxygen in the atmosphere is known to decrease the surface tension of various substances.

- ✓ Temperature \uparrow surface tension \downarrow
- ✓ At Critical temperature Surface tension: Zero
- ✓ Critical temperature of water 374K
- ✓ Surface tension Increase with impurity.



Application of surface tension

1. Digestions and Absorption of fat

- ✓ Bile salts reduce surface tension and act as detergents and cause emulsifications of fats.
- ✓ This helps in the digestion and absorptions of fats

2. hay's Sulfur test

- ✓ A test employed to detect bile salts in urine of jaundice patients.
- ✓ In this test sulfur powder sprinkles on the surface of urine with bile salts, sinking describe the detection of disease.
- ✓ In normal urine this floats.
- ✓ The principle of this test is bile salt lower the surface tension of urine which cause the sulfur to sink.

3. Surfactant and lung function

- ✓ The low surface tension of alveoli keeps them apart and allow a efficient exchange of gases in the lungs.
- ✓ Surfactant deficiency causes respiratory ditress syndrome in infants.
- ✓ Dipalmitoyl Phasphatidyl choline (Dipalmitoly lecithin) are responsible for maintaining low surface tension in the alveoli.

4. Surface tension and absorption

- ✓ Due to the coupled action of these two proceses, the formation of complexes of proteins and lipid occurs in the biological system.

5. Lipoprotein complex membrane

- ✓ The structure of plasma membrane is composed of surface tension reducing substances, amely lipid and protein.
- ✓ This facilitates absorption of these compounds.

More Application of surface tension:

- ✓ Surface tension of soap solution is less, it can spread over large areas and wash clothes more effectively, since the dirt particles stick to the soap molecules.
- ✓ In soldering, addition of flux reduces the surface tension of molten tin. Hence, it spreads.
- ✓ Antiseptics like dettol have low surface tension, so that they spread faster.
- ✓ Surface tension prevents water from passing through the pores of an umbrella.
- ✓ A duck is able to float on water as its feathers secrete oil that lowers the surface tension of water.

Biochemical Absorption

- ✓ Absorption is the process by which the products of digestion are absorbed by the blood to be supplied to the rest of the body.
- ✓ During the absorption, the digested products are transported into the blood or lymph through the mucous membrane.
- ✓ Absorption is achieved by the following mechanisms.
 1. Simple diffusion
 2. Active transport
 3. Facilitated transport.
 4. Passive transport

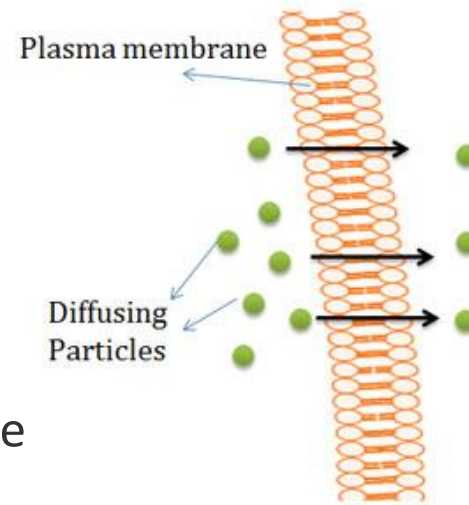
Simple diffusion

- ✓ Simple diffusion is defined as the movement of solute from the higher concentration to the lower concentration through the membrane.
- ✓ After digestion, a few monosaccharides diffuse into the blood based on the concentration gradient.
- ✓ Example: Glucose, amino acids and ions like chloride.

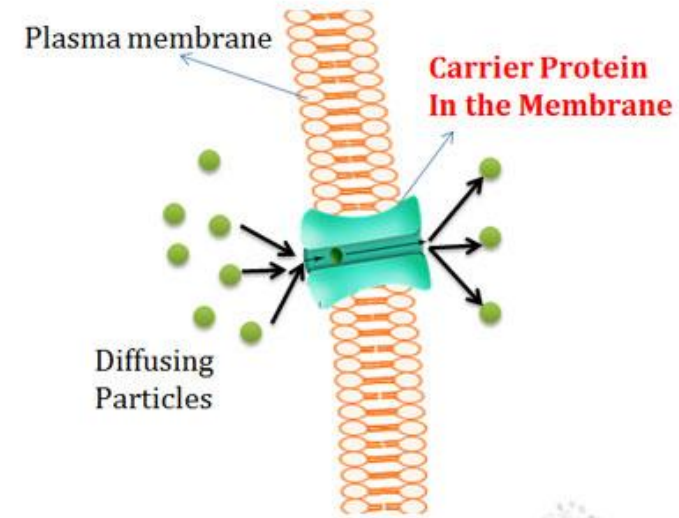
Facilitated transport

- ✓ Facilitated transport is defined as the process of movement of solutes across the biological membrane with the help of specific carrier proteins.
- ✓ Some digested amino acids and glucose are absorbed into the blood by this method.

Simple Diffusion vs Facilitated Diffusion



Simple Diffusion



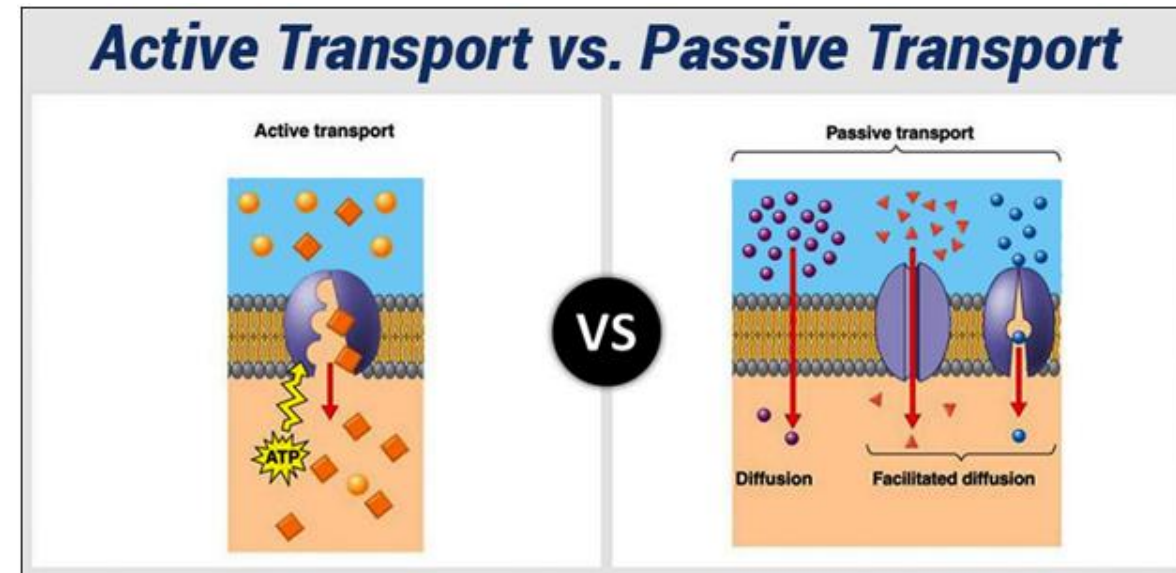
Facilitated Diffusion

Active transport

- ✓ Active transport may be defined as the process of solute movement from the lower concentration to the higher concentration by the expense of energy.
- ✓ Electrolytes like Na ions are absorbed by active transport into the blood.

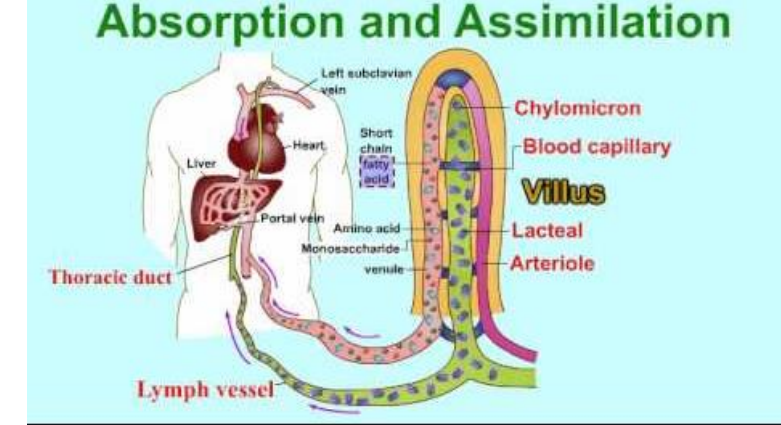
Passive transport

- ✓ Passive transport is defined as the process of solute movement across a cell membrane without a requirement of energy.
- ✓ After digestion, simpler food substance is absorbed into the blood by passive transport.



Assimilation

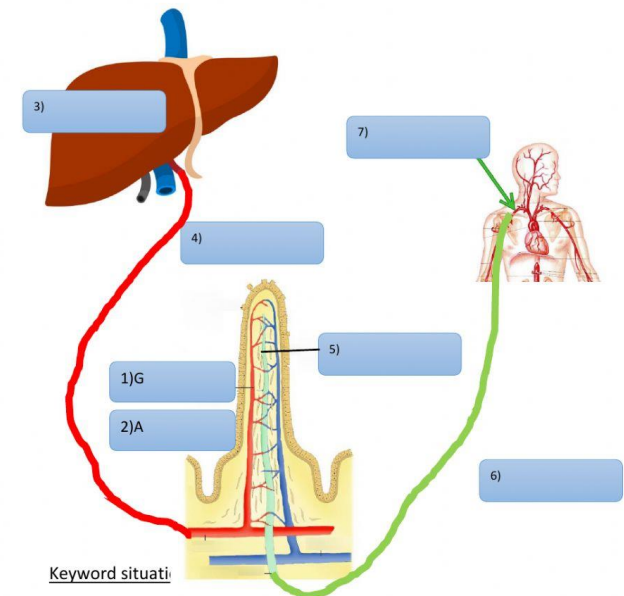
- ✓ Some digested products from fats cannot be absorbed into the blood. Example: Fatty acids and glycerol.
- ✓ These components attach to micelles which are small droplets and form the micelle-component complex.
- ✓ This micelle – component complexes are re-formed into chylomicrons. Chylomicrons are a small protein coated fat globules.
- ✓ Then, chylomicrons move into the lymph vessels and release the digested products into the blood. Finally, the digested and absorbed products reach the tissue to be utilized for their activities.
- ✓ This process is called as assimilation.



ASSIMILATION

Teacher Rohallah

Lipid	liver	Vena cava	Glucose
Hepatic portal vein	Subclavian vein	Amino acid	Lymph vessel



Keyword situasi

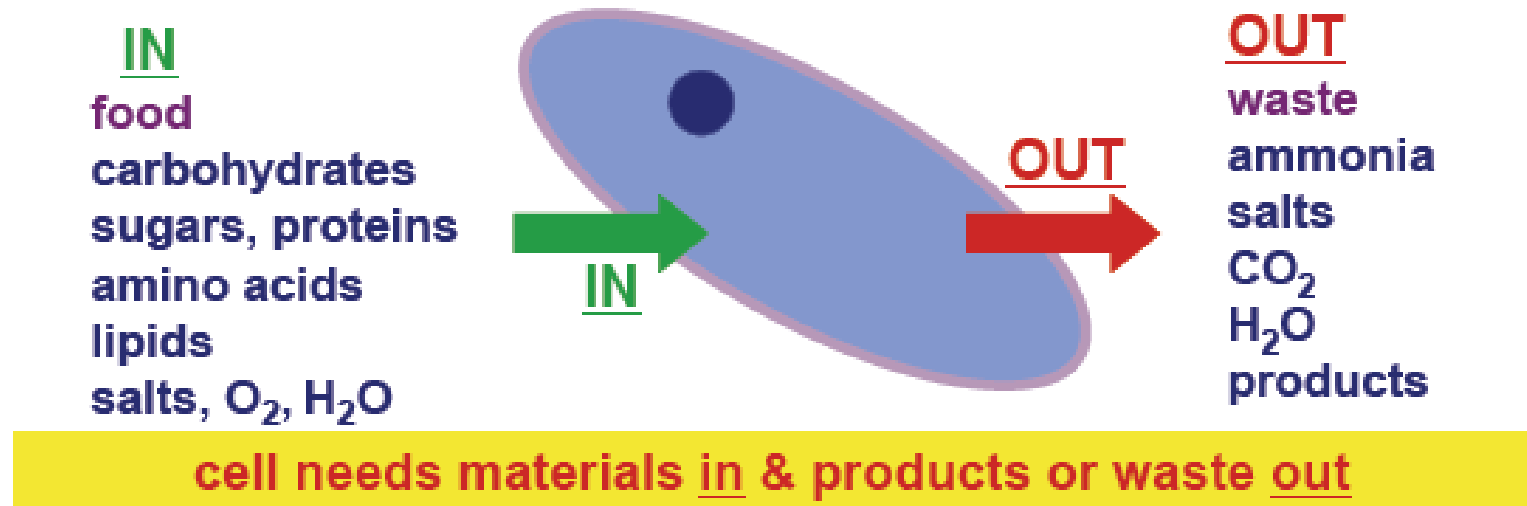
After digestion, the (1) and (2) is absorb in blood capillaries of villus, then been transport to (3) through (4). While (5) is absorb in the lacteal of villus then been transport in (6) and into the blood vessel through (5).

Structure and Function of Cell Membrane

1. Construction of Cell Membranes
2. Selective Permeability
3. Passive Transport
4. Active Transport
5. Exocytosis/Endocytosis

1. Construction of Cell Membranes

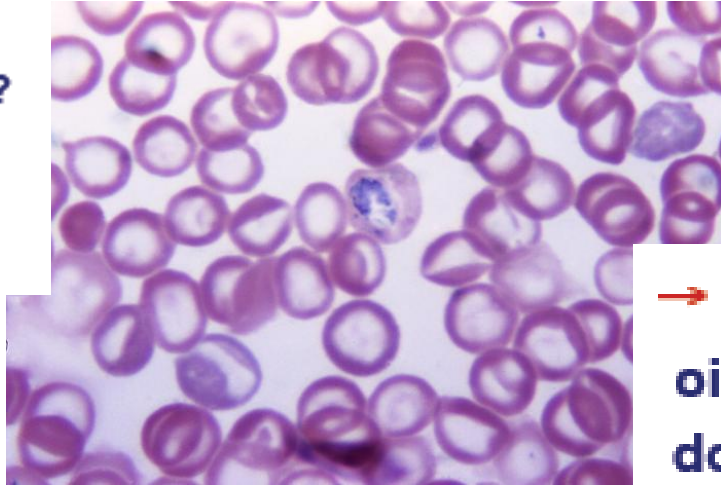
- ✓ Phospholipids
- ✓ Fluid Mosaic Model
- ✓ Proteins
- ✓ Carbohydrates
- ✓ Fluidity of Membranes
- ✓ Cells need an inside & an outside to separate the cell from its environment.
- ✓ Can it be an impenetrable boundary? **NO**



- ✓ How do you build a barrier that keeps the watery contents of the cell separate from the watery environment?

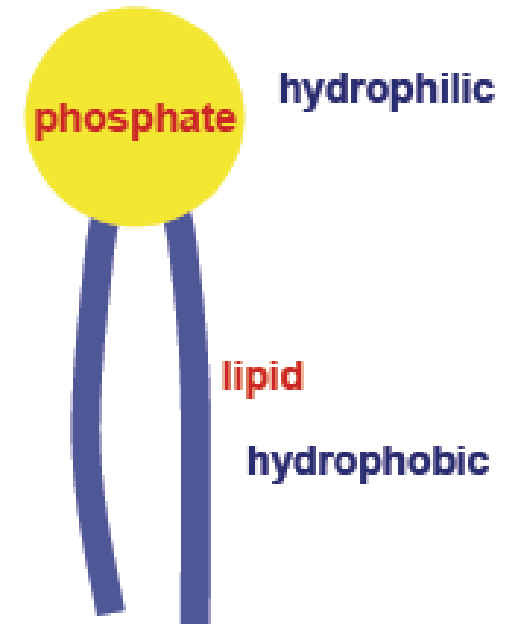
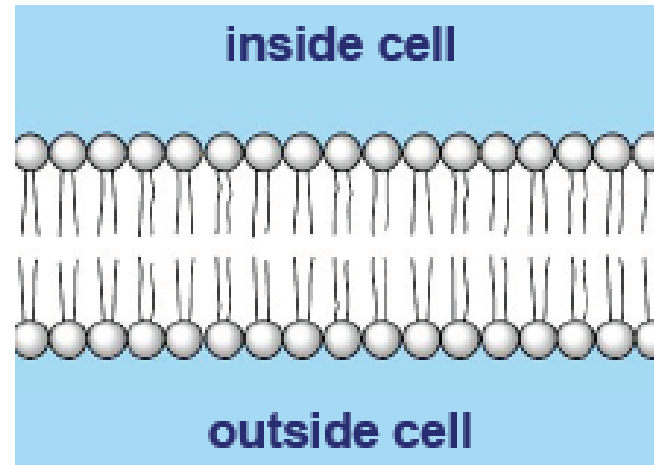
Your choices

- carbohydrates?
- proteins?
- nucleic acids?
- lipids?



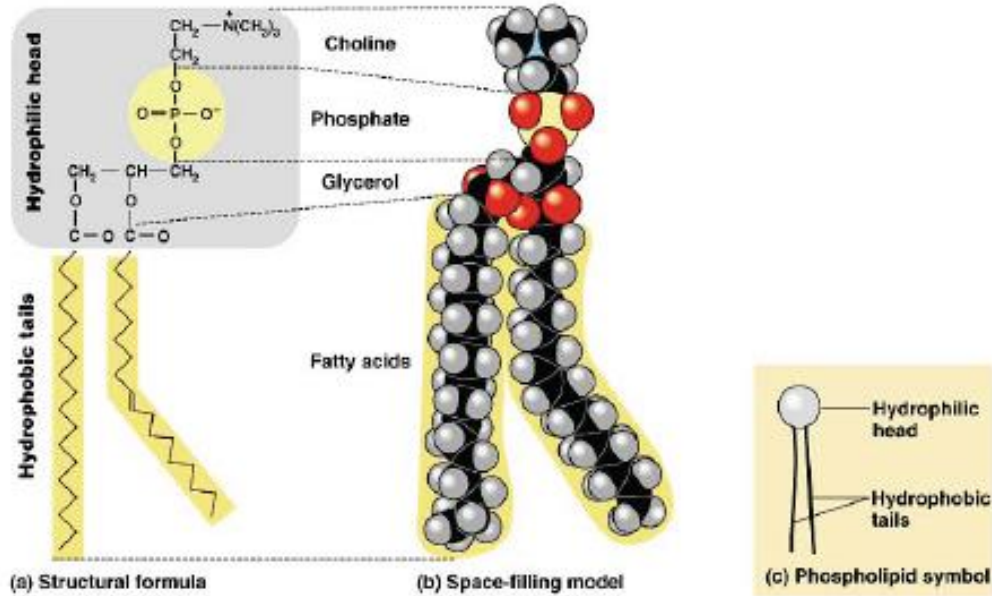
→ **LIPIDS** ←
oil & water
don't mix!!

- ✓ Cell membrane is made of phospholipids in a bilayer (by E. Gorter and F. Grendel in 1925)

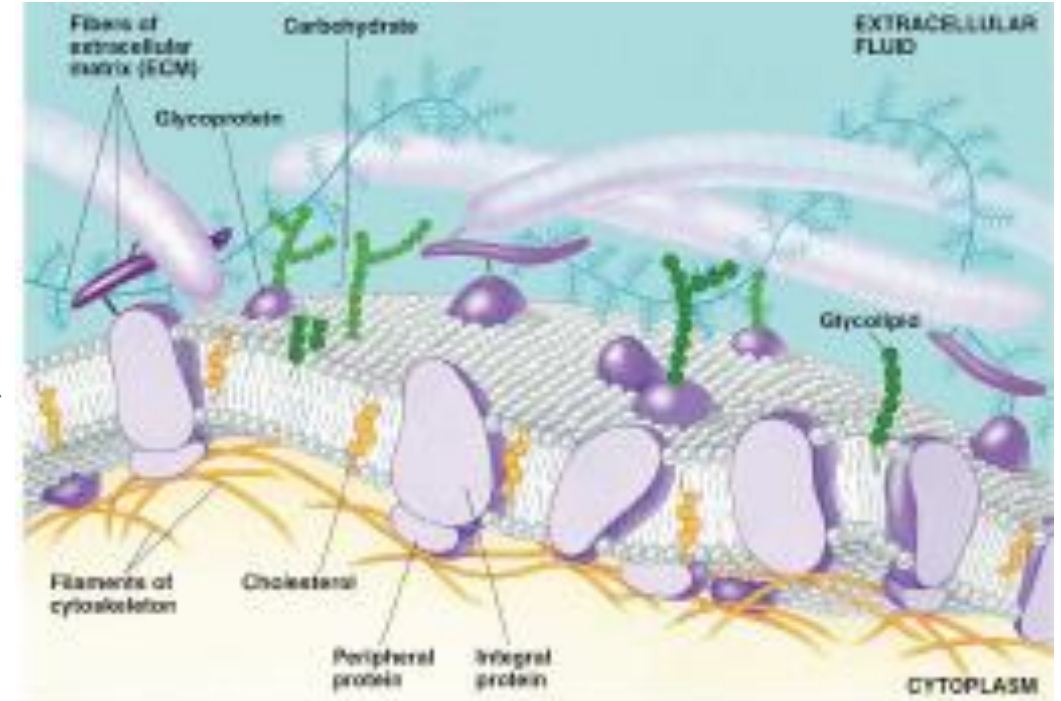
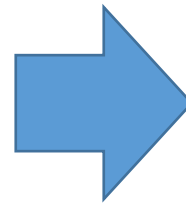
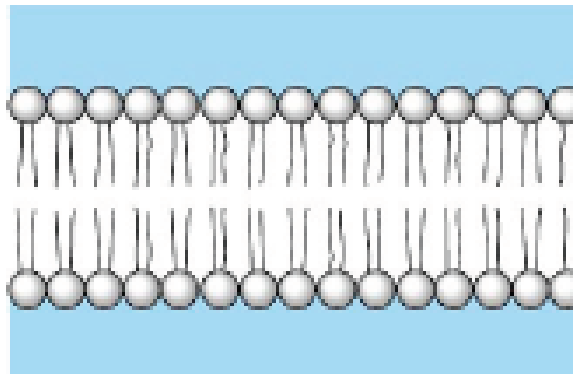


✓ Phospholipids:

Amphipathic → has hydrophobic and hydrophilic regions



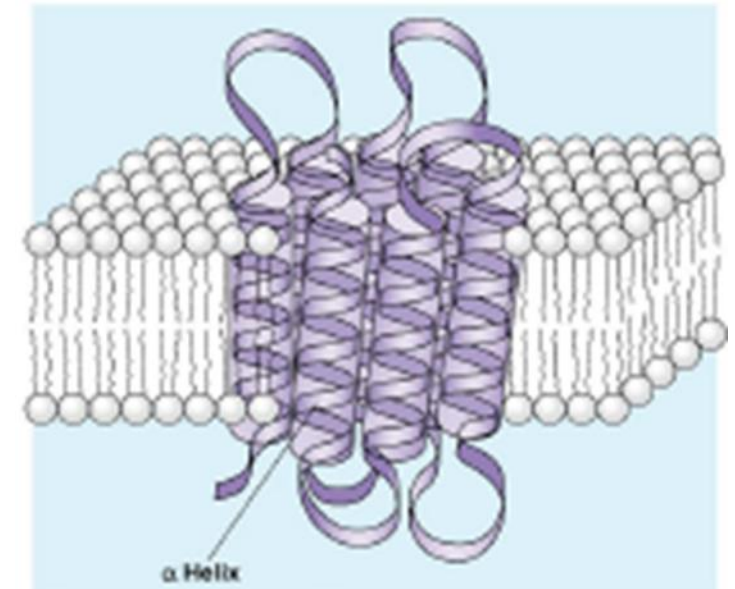
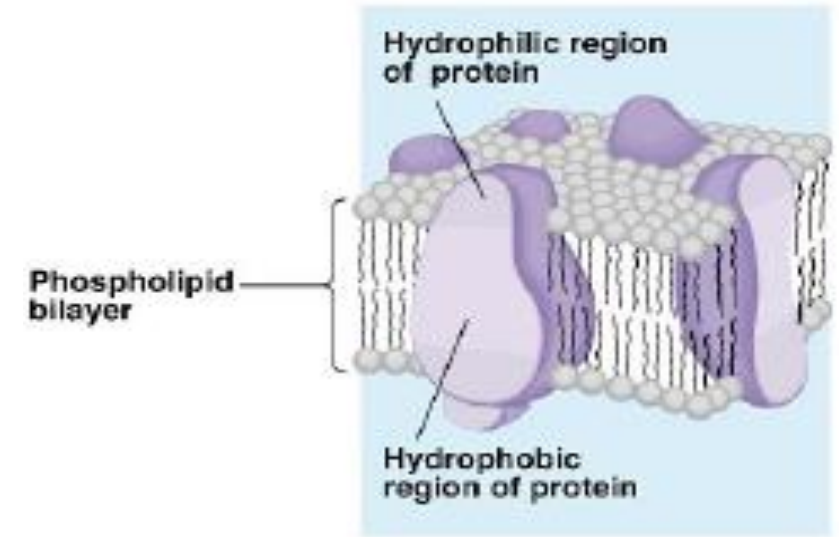
✓ But, the cell membrane is more than just phospholipids...



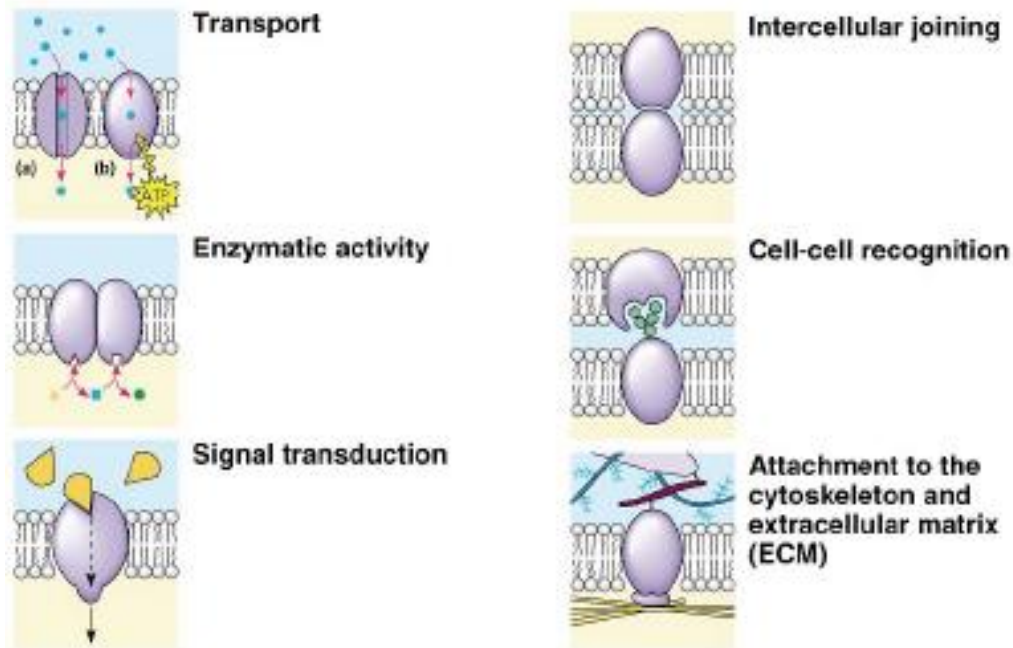
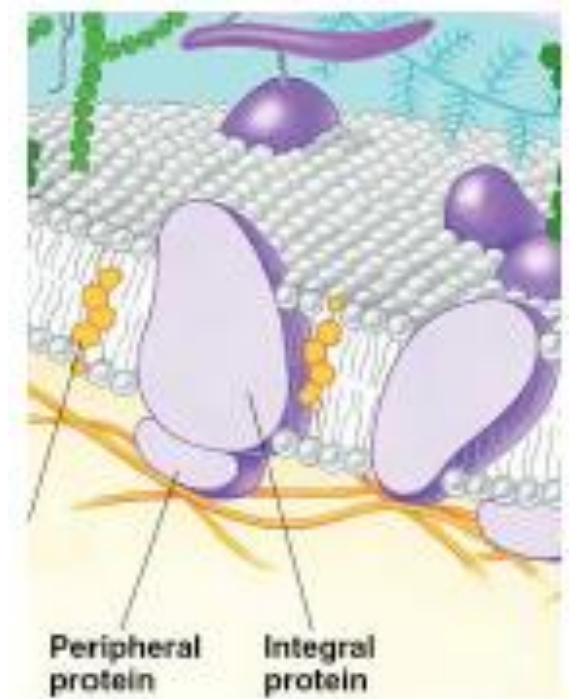
✓ S. J. Singer & G. Nicolson (1972) → proposed that membrane proteins are inserted into the phospholipid bilayer
→ called it the Fluid Mosaic Model

✓ Why Proteins?

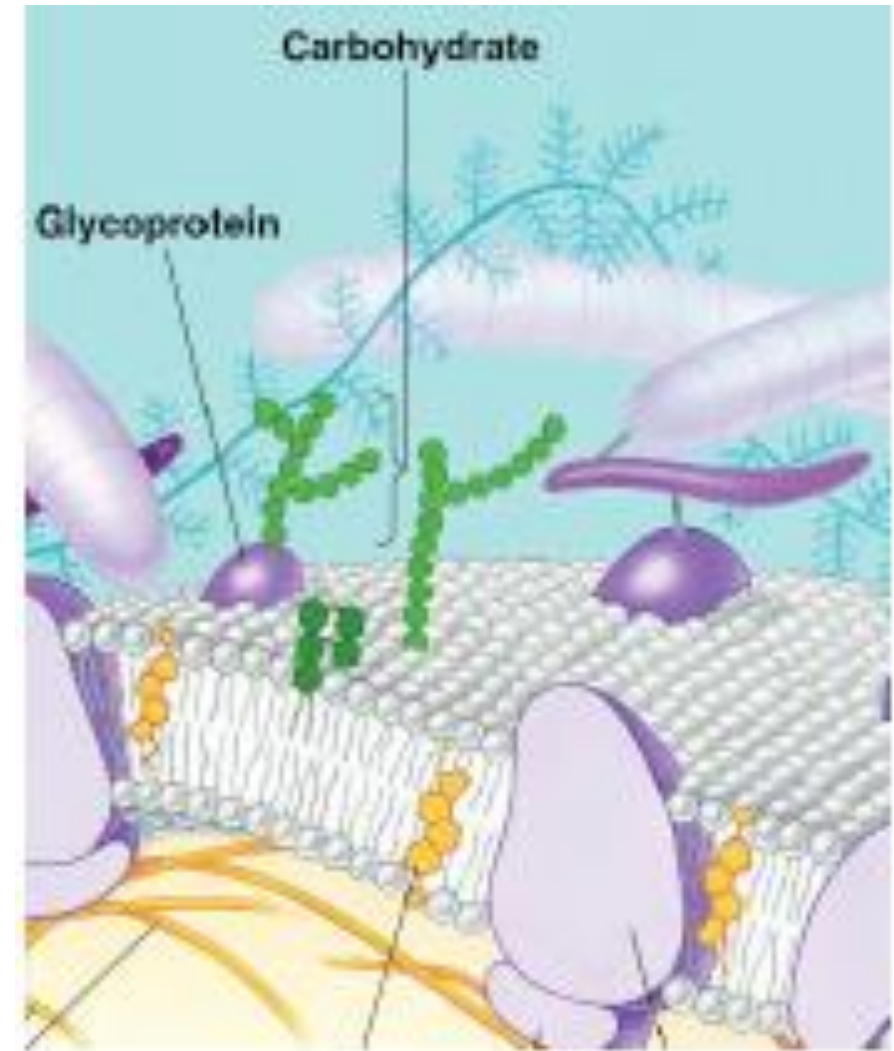
- ✓ Proteins are mixed molecules (amphipathic):
 - ✓ Hydrophobic amino acids
 - ✓ Stick in the lipid membrane
 - ✓ Anchors the protein in membrane
 - ✓ Hydrophilic amino acids
 - ✓ Stick out in the water fluid in & around cell
 - ✓ Specialized “receptor” for specific molecules



- ✓ Membrane Proteins
 - ✓ Membranes (cell & organelle) have a unique collection of proteins to determine function
- ✓ Membrane Protein Types
 - ✓ Peripheral proteins → loosely bound to surface of membrane
 - ✓ Integral Proteins → penetrate into lipid bilayer, often completely spanning the membrane (called transmembrane protein)
- ✓ Membrane proteins provide a variety of cell functions



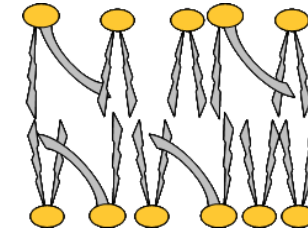
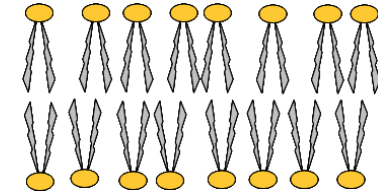
- ✓ Membrane Carbohydrates
 - ✓ Play a key role in cell – cell recognition
 - ❖ Ability of a cell to distinguish neighboring cells from another
 - ❖ Important in organ & tissue development
 - ❖ Basis for rejection of foreign cells by immune system
 - ✓ Can be:
 - ❖ Glycolipids (carb + lipid)
 - ❖ Glycoproteins (carb + protein)



Selective Permeability

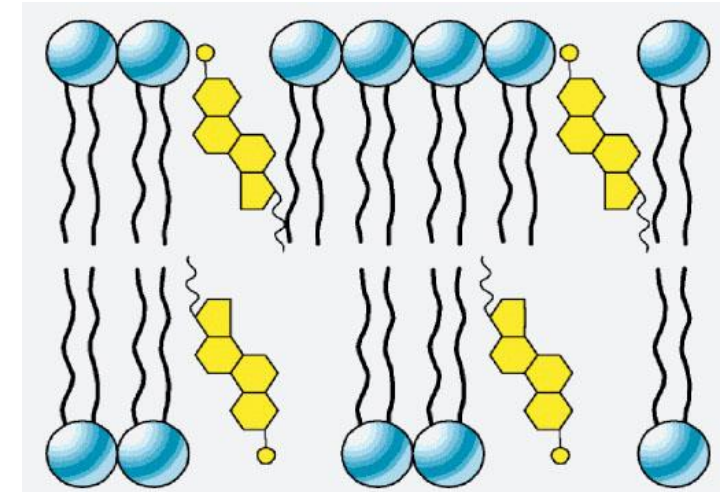
✓ Fluidity of Membranes

- ✓ Due to the types of hydrocarbon tails at the tip of each phospholipid
 - ✓ Saturated hydrocarbon tails → packed tightly together & less fluid
 - ✓ Unsaturated hydrocarbon tails → have kinks in molecule which keeps molecules from being tightly packed → enhanced fluidity



✓ Fluidity of Membranes – Animal Cells

- ✓ Have cholesterol embedded in cell membranes
 - ✓ which further changes fluidity by restraining phospholipid movement
 - ✓ 37°C (body temp) → resists fluidity



- ✓ Construction of membrane allows for some substances to pass through membrane without resistance.
 - ✓ Nonpolar molecules (hydrocarbons, CO_2 , O_2) → hydrophobic; can dissolve in lipid bilayer
 - ✓ Polar molecules (ions, H_2O) → core of membrane stops passage
 - ✓ Large polar molecules (glucose) → passes very slowly
- ✓ Thus, membrane is said to be semi-permeable
 - ✓ Controls what enters and exits cell
 - ✓ What types of things does the membrane control?

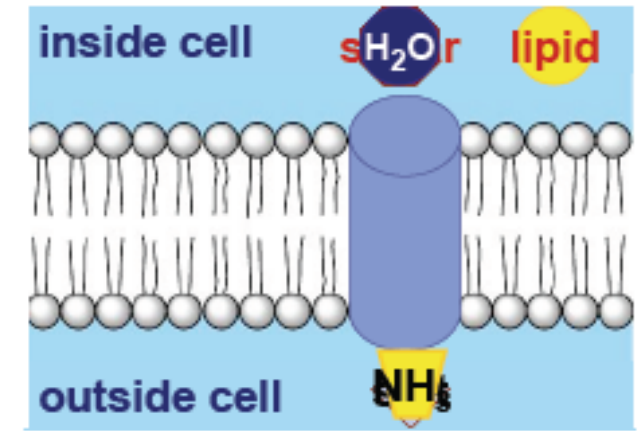


- ✓ How do you build a semi-permeable membrane?

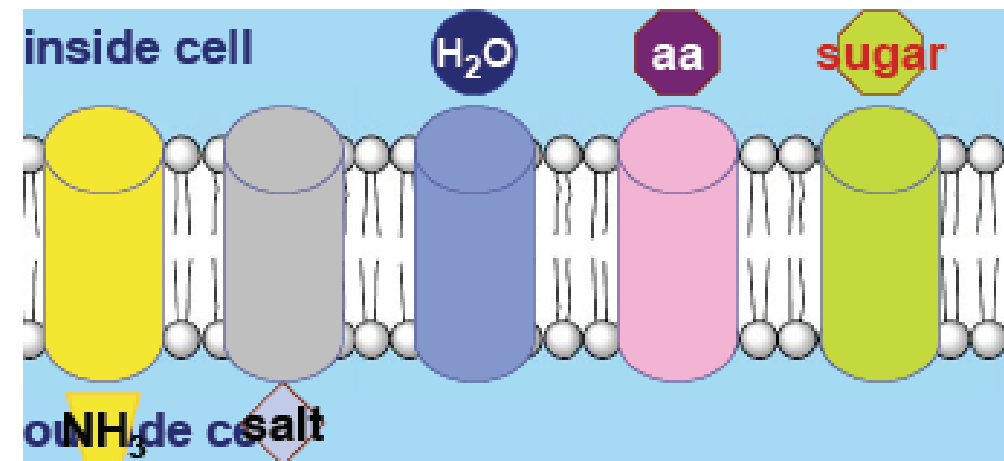
- ✓ Membranes need to be permeable to:
 - ✓ Bring in all materials a cell needs
 - ✓ Excrete out all cellular (metabolic) waste
 - ✓ Export out all products a cell makes

“holes”, or channels, in cell membrane allow material in & out

AP Biology

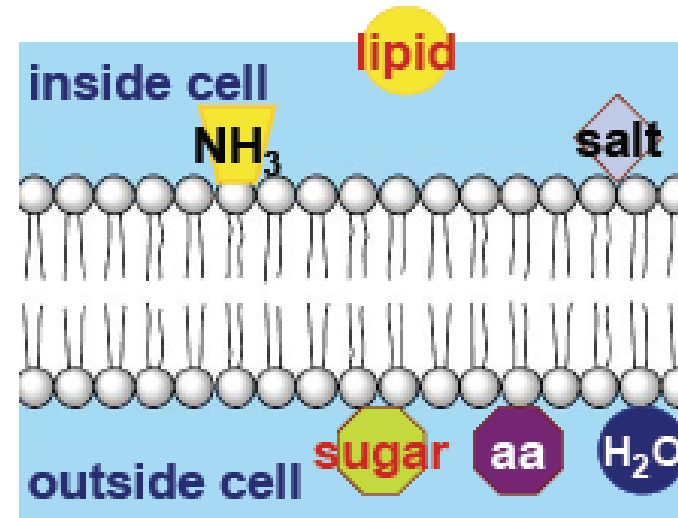


- ✓ Proteins act as channels to move molecules
- ✓ To remain in control of the semi-permeable nature of the membrane, specific channels allow specific material in and out



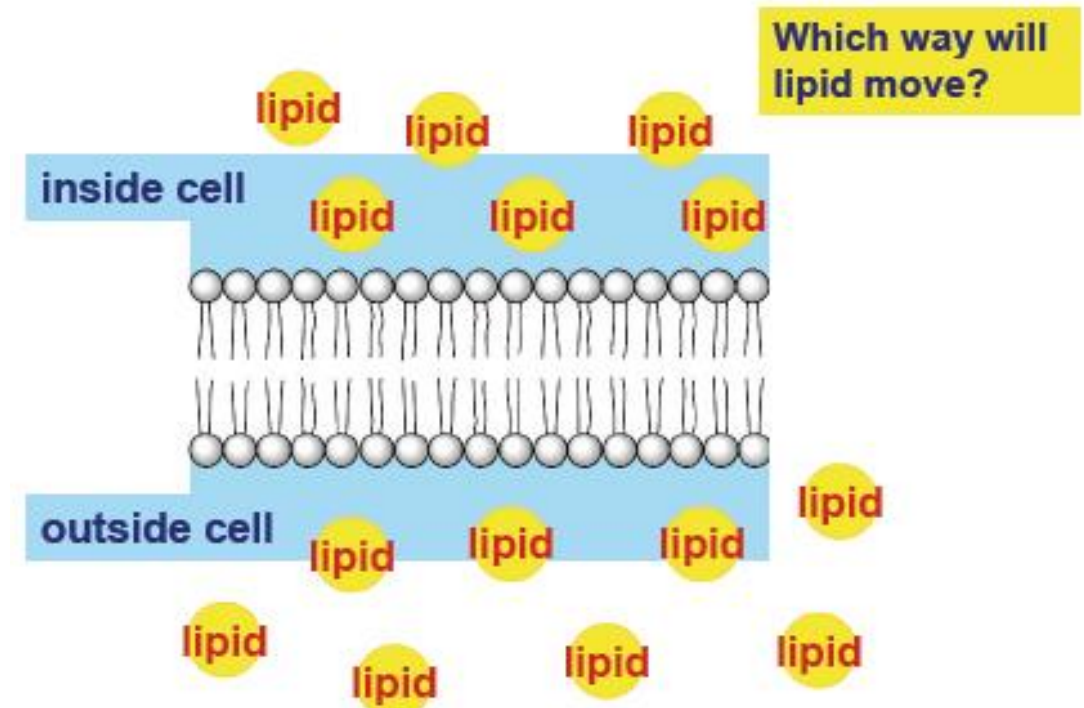
3. Passive Transport

- ✓ Diffusion
- ✓ Facilitated Diffusion
- ✓ Osmosis
- ✓ Movement of molecules through the membrane with the concentration gradient (from high to low concentration)
- ✓ Does not use energy
- ✓ Movement continues until equilibrium is reached
- ✓ What molecules can get through membrane directly?
- ✓ Lipids diffuse across the membrane.



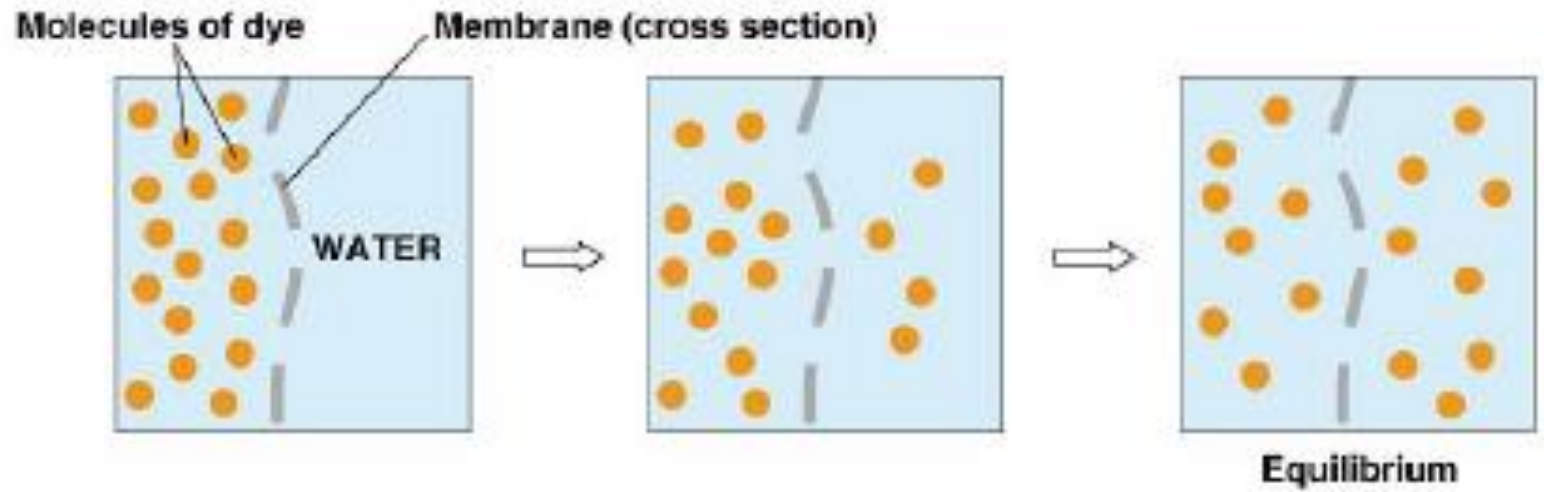
**fats & other lipids
can slip directly
through the
phospholipid cell
membrane, but...**

**what about other
stuff?**



✓ Diffusion: movement of particles from high → low concentration

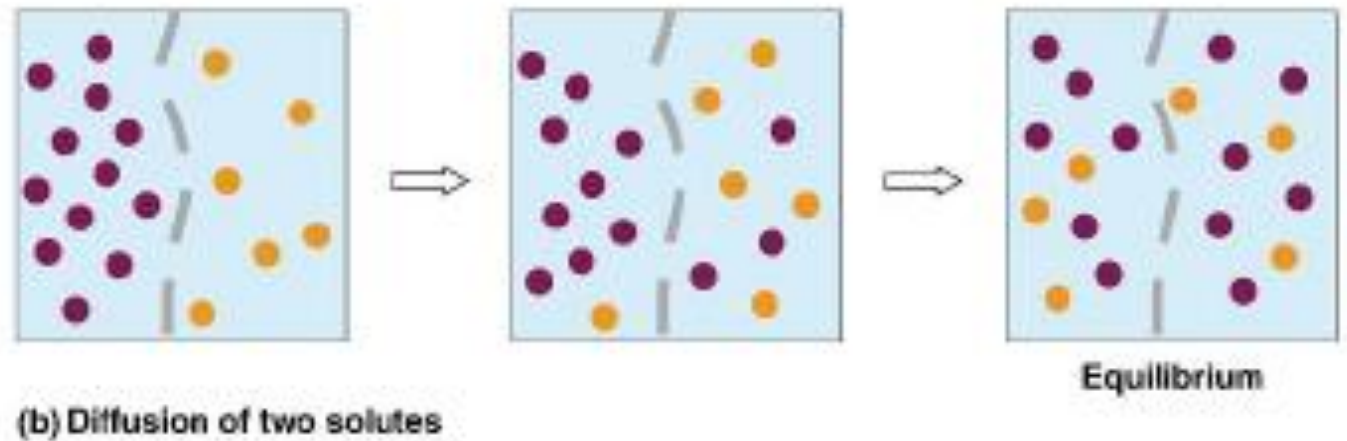
✓ follows 2nd law of thermodynam



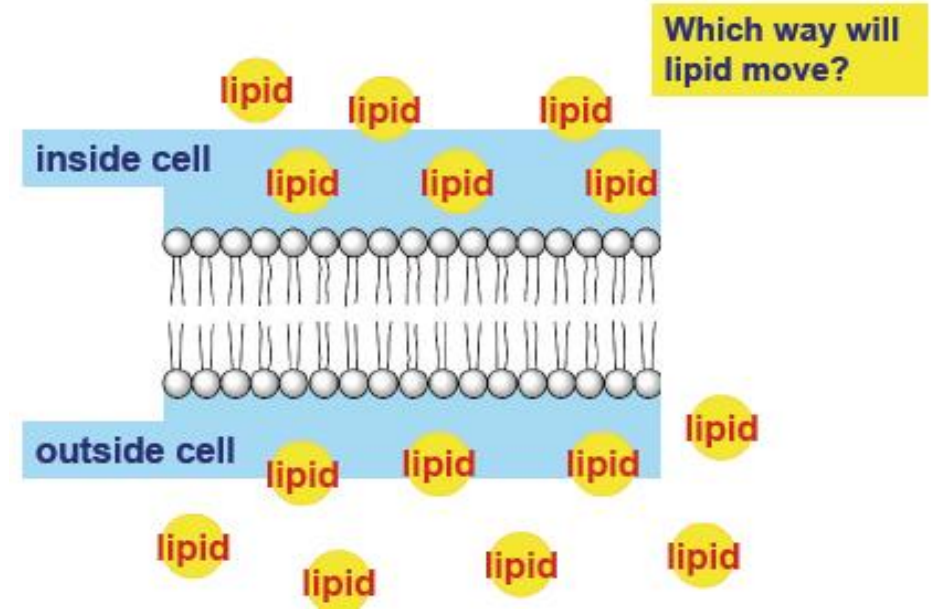
✓ Diffusion of multiple substances:

✓ Each substance diffuses down its own concentration gradient (at different speeds)

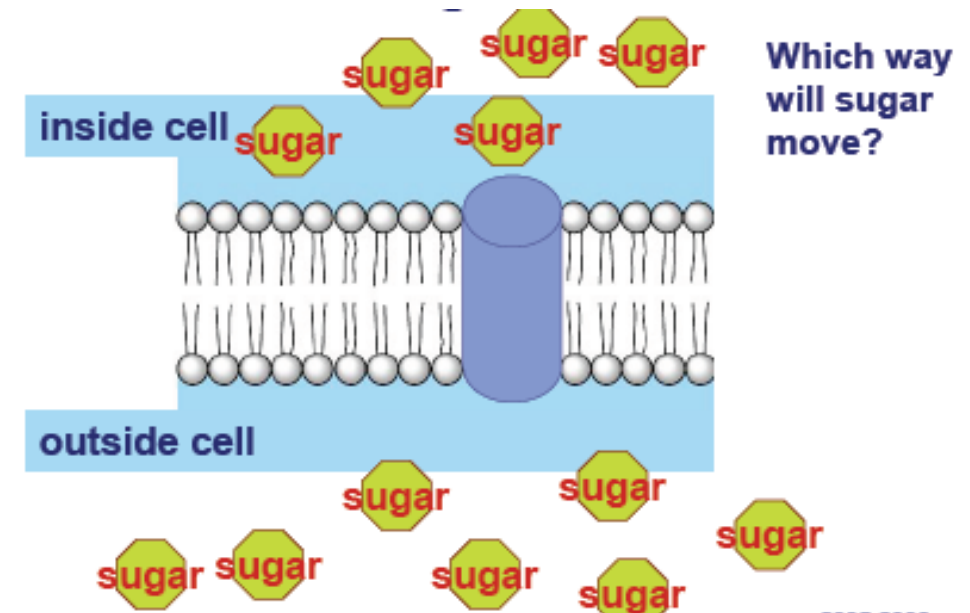
✓ Independent of each other



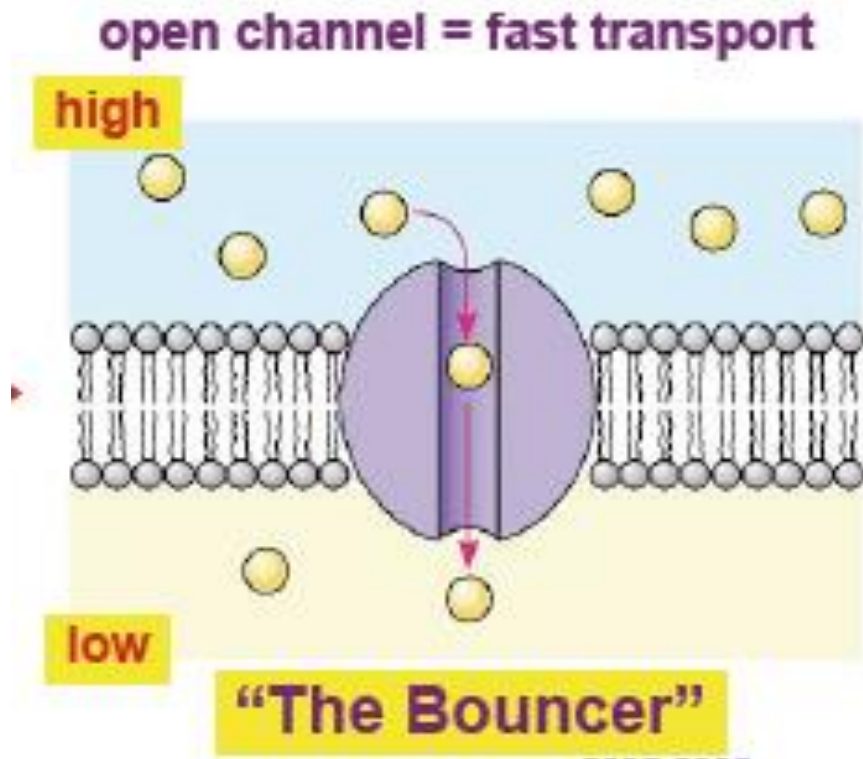
✓ So...back to our question...



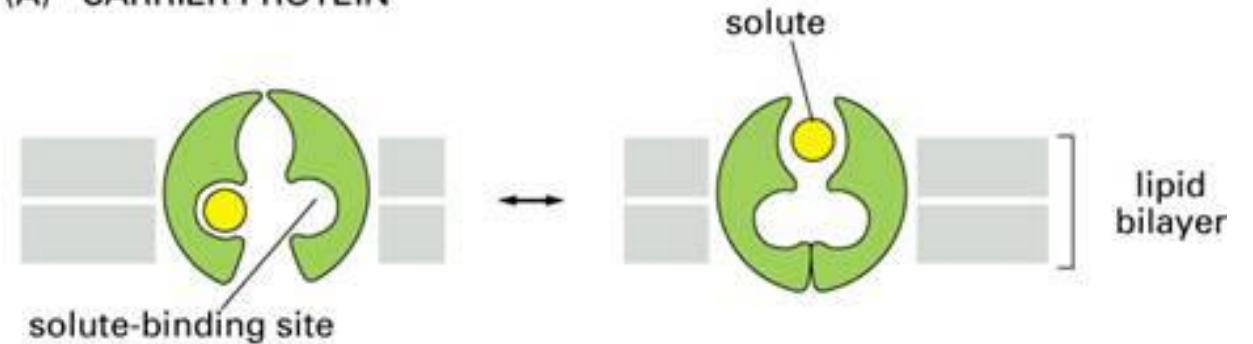
✓ Movement of sugar through a protein channel



- ✓ Facilitated Diffusion: movement of larger particles and ions across the cell membrane aided by protein channels
 - ✓ Channel proteins → corridors for specific molecules
 - ✓ Water Channels → Aquaporins
 - ✓ Ion Channels → gated channels to regulate ion movement; open upon electrical stimulus
 - ✓ Carrier proteins → has a shape interaction that binds substrate to protein to cross membrane



(A) CARRIER PROTEIN



(B) CHANNEL PROTEIN

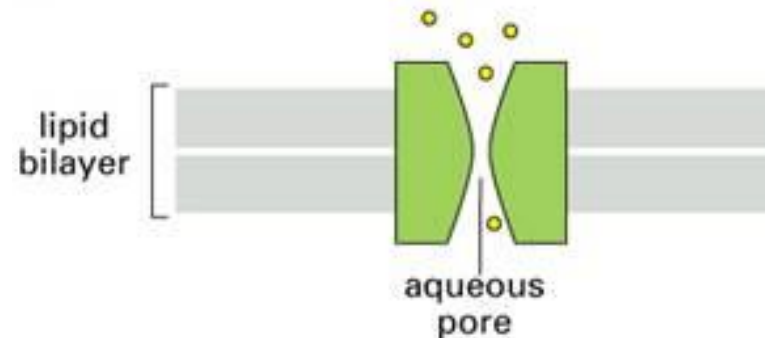
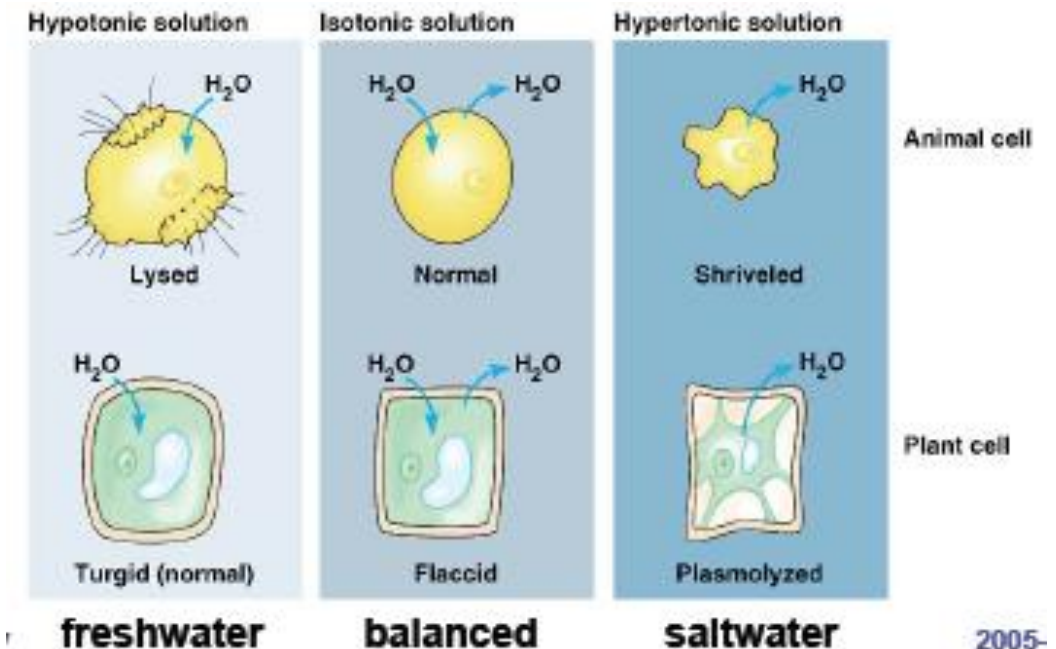
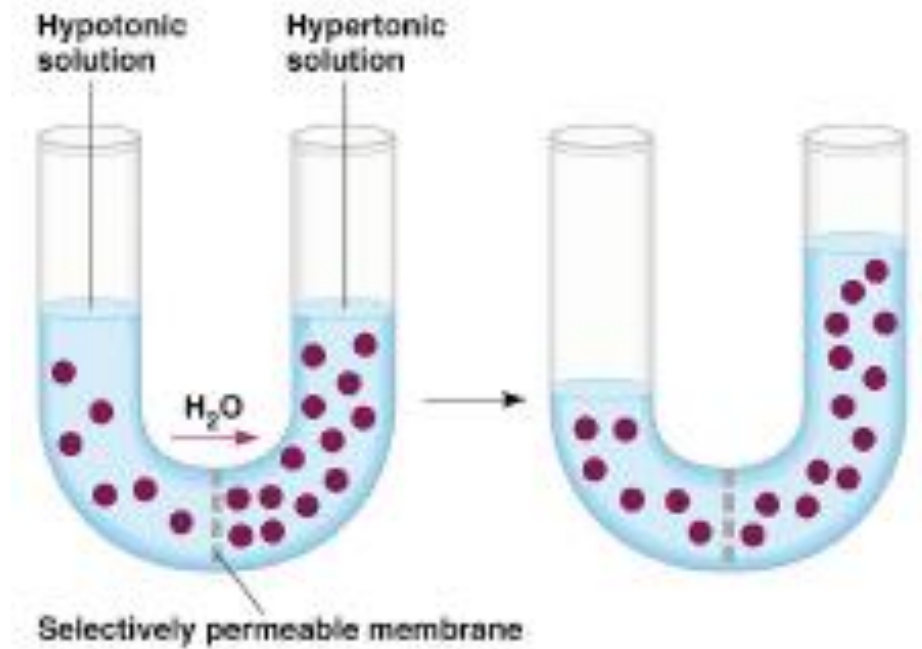
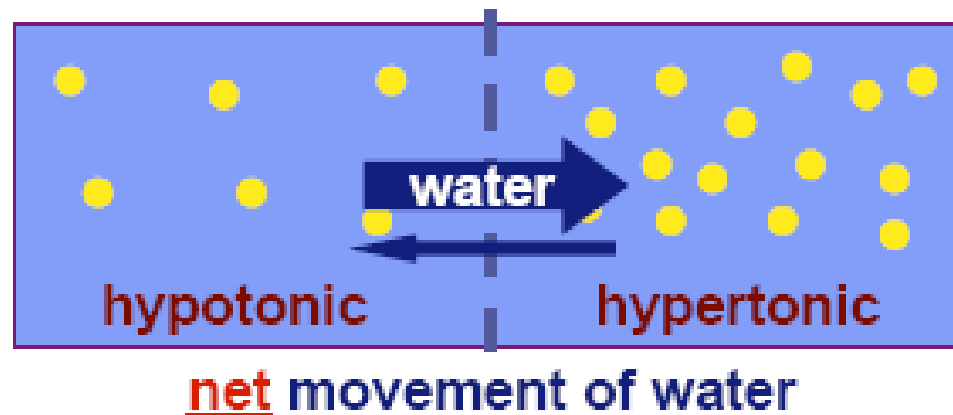
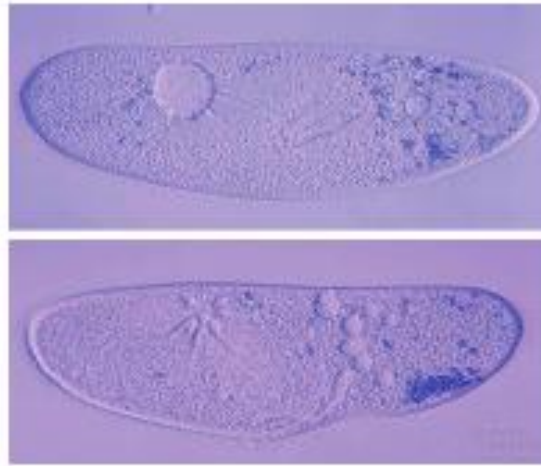


Figure 11-3. Molecular Biology of the Cell, 4th Edition.

- ✓ Osmosis: diffusion of water from high to low concentration across a semi-permeable membrane
- ✓ Direction of osmosis is determined by comparing total solute concentrations
 - ✓ Hypertonic = more solute, less water
 - ✓ Hypotonic = less solute, more water
 - ✓ Isotonic = equal solute, equal water
- ✓ Cell survival depends on balancing water uptake & loss



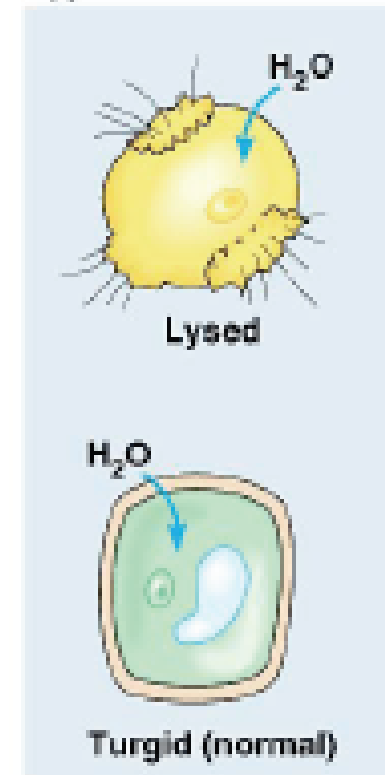
- ✓ Isotonic Solutions
 - ✓ No net movement of water across plasma membrane
 - ✓ Water flows across membrane, at same rate in both directions
 - ✓ Volume of cell is stable
 - ✓ EX: blood cells in blood



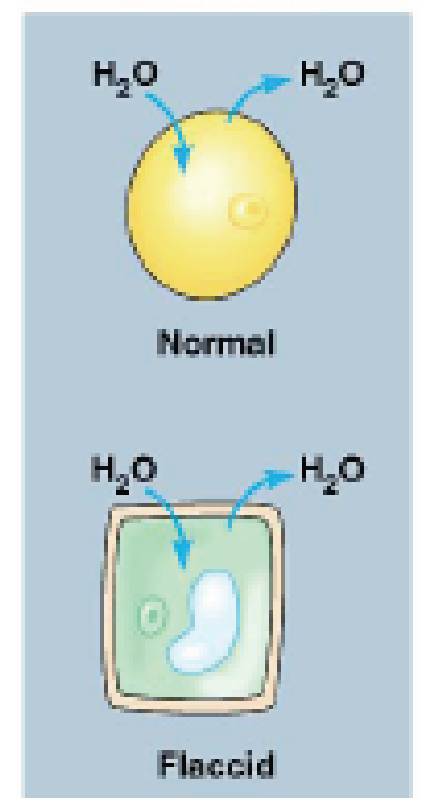
- ✓ Contractile vacuole in *Paramecium* (HYPOTONIC)

- ✓ Animal cells → gain water, swell, & burst
 - ✓ *Paramecium* vs. pond water
 - ✓ *Paramecium* is hypertonic
 - ✓ Water constantly enters cell
 - ✓ Has a contractile vacuole to constantly pump water out of cell (ATP)
- ✓ Plant cell → makes cell turgid

Hypotonic solution



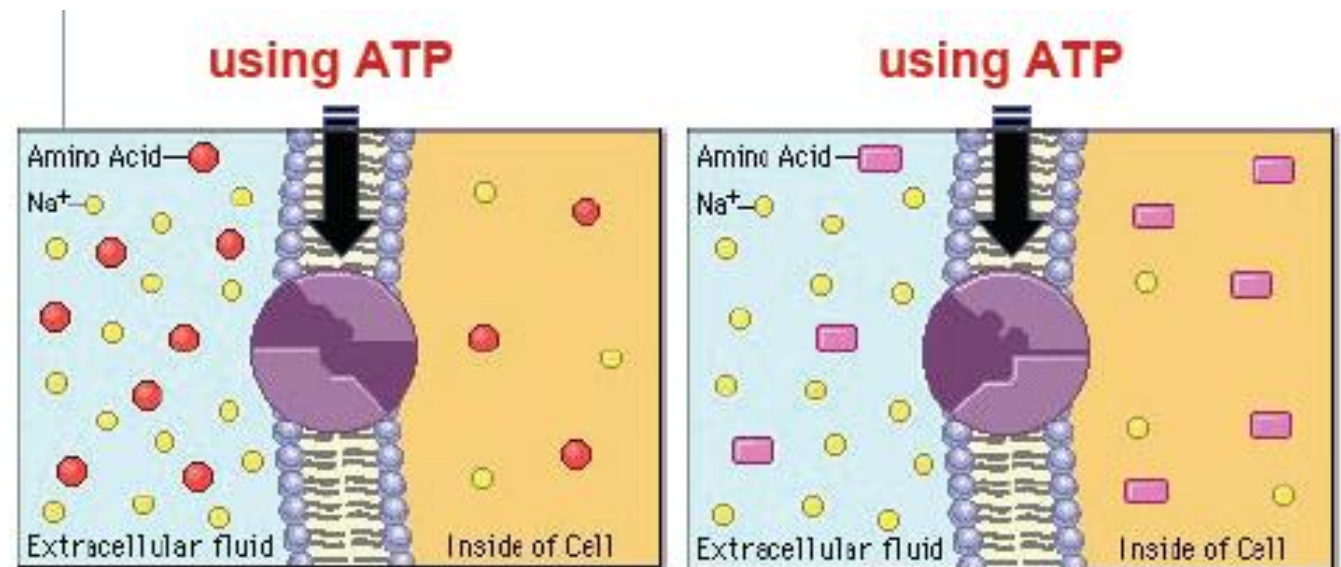
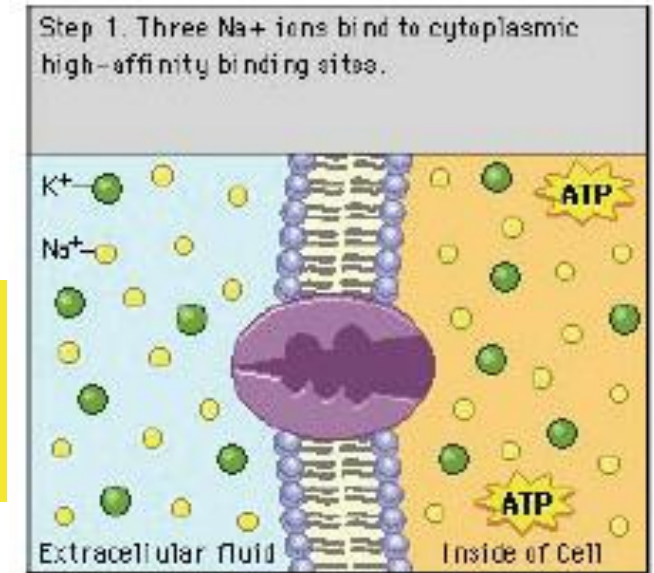
Isotonic solution



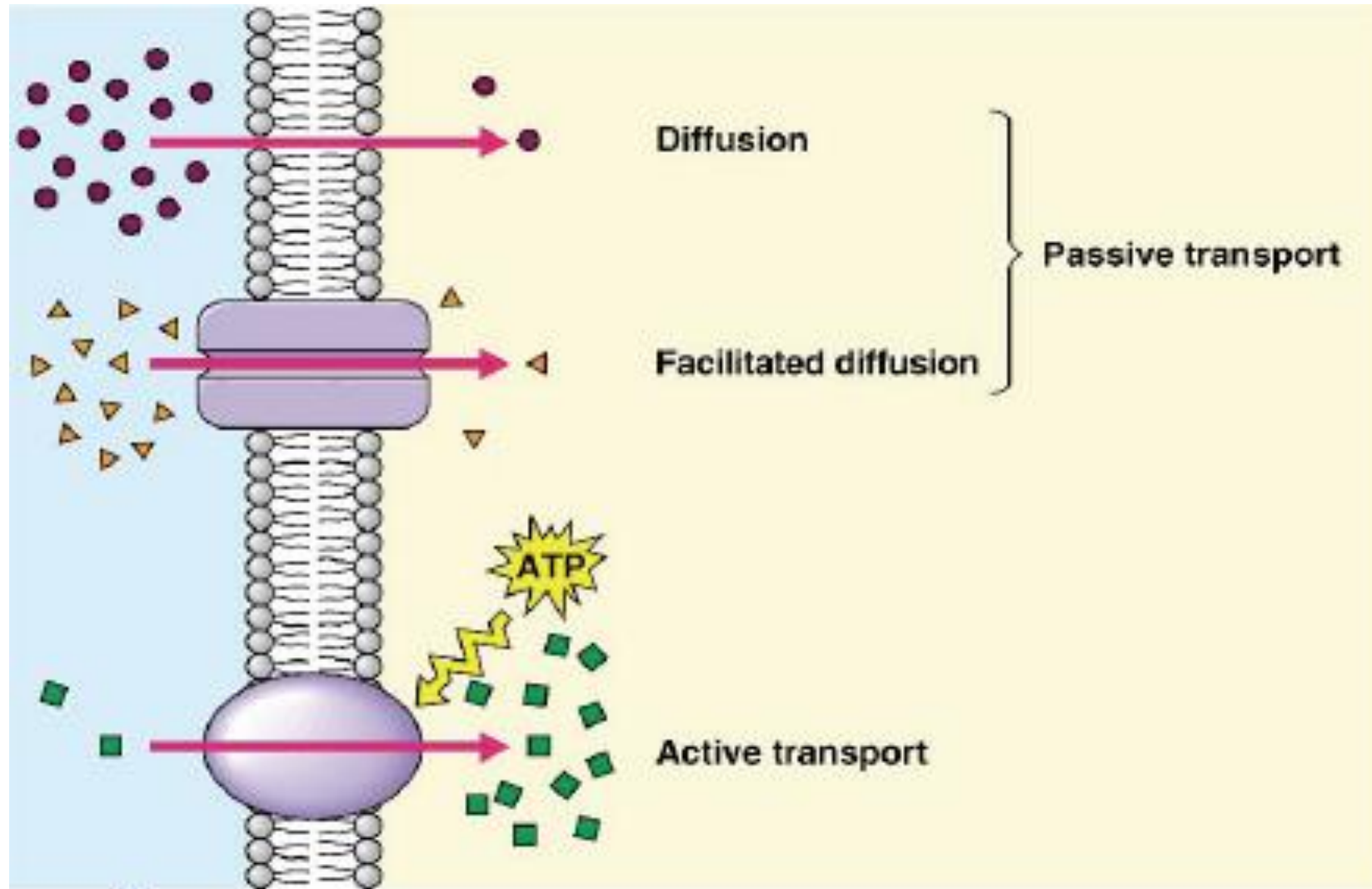
Active Transport

- ✓ Cells may need to move molecules against the concentration gradient
 - ✓ From low to high concentration
 - ✓ Need a protein pump to move molecules
 - ✓ REQUIRES ENERGY (ATP)
- ✓ Has many models and mechanisms

Na⁺/K⁺ pump in nerve cell membranes



Transport Summary



Endocytosis/Exocytosis

- ✓ Movement of large molecules into and out of cell
 - ✓ Through vesicles and vacuoles

Endocytosis

- ✓ Phagocytosis = “cellular eating” via lysosome
- ✓ Pinocytosis = “cellular drinking”
- ✓ Receptor-mediated endocytosis → triggered by ligand signal

Exocytosis

- ✓ Using a secretory vesicle to remove food, wastes from cell

